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ORIGINAL ARTICLES.

I.—Note on the Molar of a Trilophodont Mastodon from the Base of the Suffolk Crag.

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Director of the Natural History Departments of the British Museum.

(PLATE XI.)

THE tooth figured in the accompanying plate was originally noticed by me in this Magazine thirty years ago, and was more fully described by me a year later in the Quarterly Journal of the Geological Society, 1870, p. 507.

At that time it was in the collection of Mr. Baker, of Woodbridge. It has since passed into the collection of the York Museum. I am greatly indebted to the authorities of that institution for lending it to me again for further study, and for allowing me to remove from the valleys between the transverse ridges of the tooth the remarkable matrix which formerly filled them up. (Compare the figure in the Quart. Journ. Geol. Soc., 1870, with that now published.)

The interest attaching to this tooth is twofold. In the first place it was determined by me to be the upper penultimate molar of a Trilophodont Mastodon, being a perfect enamel crown from which no portion had been detached. It thus differs from the well-known Tetralophodont Mastodon of the East Anglian area (*M. Arvernensis*). The completeness of the tooth-crown was recognized by all the palæontologists who saw the actual specimen, including the late Mr. George Busk, F.R.S., whose testimony on the subject I cited.

The second point of interest about the tooth is that its valleys were filled by a matrix which I was able to identify with the sandstone nodules called 'box-stones,' the true nature of which I had recently determined by collecting from every available source the shell-casts and other organic remains which they contain. It was shown that the 'box-stones' which occur abundantly at the base of the Suffolk Crag (and not in the Norfolk area) are the rolled fragments of a Diestien deposit, in all probability an extension of the Black Crag of Antwerp. The Trilophodont Mastodon was therefore necessarily a tenant of the land surface before the deposition of this Upper Miocene 'Black Crag.' In this respect it

was shown to contrast with *Mastodon Arvernensis*, the teeth of which occur at the base of both the Suffolk and Norfolk Crags in a peculiar condition of mineralization, differing widely from that of the present specimen and from that of some other fragments of Mastodon teeth not referable to the species *M. Arvernensis*. The molars of *M. Arvernensis* from the East Anglian area are very seldom water-worn, and in many cases are found, not in the condition of 'enamel crowns,' but with the softer material which forms the fangs of the tooth still perfect. On the other hand, the teeth of *Rhinoceros Schleiermacheri*, of *Tapirus priscus*, of *Hipparion*, and some other mammals, which occur in the same deposit, are in the same water-worn condition and in the same state of mineralization as that which characterizes this Trilophodont Mastodon and some other fragments of Mastodon teeth referred by me to *M. tapiroides*. The conclusion to which I came was, that we have at the base of the Suffolk Crag successive sweepings (as it were) of the land surface, the latest (Pliocene) being represented by *M. Arvernensis* and possibly some other remains, an older sweeping by the Trilophodont Mastodon, other Mastodon fragments, and the *Rhinoceros*, *Hipparion*, and *Tapirus*, whilst a still older contribution is that of the Eocene land fauna indicated by *Coryphodon* and *Hyracotherium*.

The specific identification of the single penultimate Trilophodont molar was a difficult task, especially as the valleys were filled by matrix. After discussing the possible identification of the tooth with *M.* (*Trilophodon*) *Borsoni*, a Pliocene species, I came to the conclusion that the probabilities were in favour of its being referable to *M.* (*Trilophodon*) *tapiroides* (= *turicensis*, Pom.).

The chief reason which I have had for making a re-examination of this specimen is, that my main conclusion as to its nature has been directly traversed in two separate publications by Mr. R. Lydekker, F.R.S. I find that Mr. Lydekker had never examined the original specimen, but based his opinion on a coloured cast which I had presented to the British Museum. This cast did not show the under surface of the specimen at all, and therefore was devoid of any evidence which could justify the formation of an opinion as to the completeness or incompleteness of the enamel crown.

In a paper on Crag Vertebrata, Mr. Lydekker writes as follows (in the Quart. Journ. Geol. Soc., vol. xlii, p. 365, 1886) :—"The evidence for the presence of *M. longirostris*, Kaup, is afforded by several fragments of molars in the British Museum,[1] and by the greater part of a second or third upper true molar[2] figured by Lankester in vol. xxvi, pl. xxxiv, figs 1, 2, of the Society's Journal, and regarded by him as the complete tooth of a Trilophodont species. The examination of the cast of the latter shows, however, without doubt, that it has lost one or more posterior ridges, and that, as suggested by Lartet,[3] it really belongs to *M. longirostris*, the form

[1] These and the preceding specimens were noticed by Lydekker in part iv of the British Museum Catalogue of Fossil Mammalia.

[2] Cast in British Museum.

[3] See Lankester, op. cit., p. 508.

of the anterior talon and the separation of the inner and outer columns being decisive."

In the fourth volume of the Catalogue of Fossil Mammalia, published by the Trustees of the British Museum (1886), p. 65, Mr. Lydekker records the cast presented by me as No. 48,427 in the collection, and declares it to be a cast of the first three ridges of the second or third left upper true molar of the Tetralophodont *Mastodon longirostris* of Kaup. He states that the original is described and figured by Lankester as the complete molar of a Trilophodont species, and proceeds—"The specimen has, however, lost a ridge, and agrees precisely with the corresponding portion of the molars of the present species (*M. longirostris*)." In a note Mr. Lydekker refers to Lartet's opinion of the 'specimen.' But as a matter of fact Mr. Lartet had never seen the specimen any more than had Mr. Lydekker. Both of them based their opinions on a very incomplete cast of a specimen, which was still largely obscured by matrix, and had never been seen by either of them.

There never was any doubt in my own mind as to the completeness of the enamel crown under discussion, and I am glad to be able to state that on examining the actual specimen, lent to me by the authorities of the York Museum last autumn, Mr. Lydekker at once admitted that the enamel crown *is* complete, and that his contention that it was not so is devoid of any foundation.

During its sojourn in the British Museum (Natural History) our skilled 'preparateurs' have removed from the 'Baker' molar the mass of matrix which filled up the two valleys. It is now, therefore, a more hopeful task than was the case thirty years ago, to attempt to arrive at a conclusion as to the species of Trilophodont Mastodon to which it should be referred.

The clearing out of the matrix from the valleys in our specimen has shown that the transverse ridges and valleys have by no means the simple and clean-cut character which is found in those of *Mastodon Borsoni*. The semi-detached columns on the sides of the first and second ridges and the sharp median incision traversing the whole tooth antero-posteriorly place this tooth in that middle group of Mastodons (so far as ridge structure is concerned) occupied by *Trilophodon angustidens* and *Tetralophodon longirostris*, a group lying between the simpler *Trilophodon Americanus* and *Trilophodon Borsoni* and the complicated *Trilophodon Humboldti* and *Tetralophodon Arvernensis*.

The *Trilophodon angustidens* of Cuvier is a Middle Miocene form to which several other species are related, perhaps only as local specializations. *M. Pyrenaicus* of Falconer and *M. tapiroides* (*turicensis*) are not remote from it. Specimens are preserved in the various museums of Europe which afford an almost complete transitional series between these three species. The most striking difference between *M. angustidens* and the two others is, that it has really narrow molars whilst the others have broad ones. Our Suffolk molar is remarkably broad in proportion to its length, broader, I should say, than any penultimate upper molar I have seen.

It has not so well developed a cingulum as have typical molars of *M. tapiroides* (*turicensis*), and the ridges are not so high in proportion to the other dimensions of the tooth. In place of the oblique fold of enamel traversing the face of each ridge which is seen in *typical* (but not in all) specimens of molars referred to *M. tapiroides*,[1] we have here a breaking up of the transverse ridge itself into semi-detached columns. On the whole it comes nearest amongst described molars to those called *M. Pyrenaicus* by Falconer. This *M. Pyrenaicus* is essentially a *Mastodon angustidens* which is not angustident, and that perhaps is the best description which can be given of the present tooth. I should be inclined, supposing that the species '*M. Pyrenaicus*, Falc.,' is to be considered as a synonym of *M. angustidens*, Cuv., to recognize such broad molars of the *M. angustidens* type as belonging to *Mastodon angustidens*, Cuv., var. *latidens*.

In any case we have to go to the Middle Miocene for the species with which to associate this Suffolk Mastodon, and this fact is well in harmony with the age indicated by the once adhering matrix, viz., one anterior to that of the Diestien or Black Crag of Antwerp.

EXPLANATION OF PLATE XI.

Fig. 1, view of the upper surface, and Fig. 2, side view of the trilophodont upper penultimate molar of *Mastodon angustidens*, var. *latidens*, from the base of the Red Crag of Suffolk, preserved in the Yorkshire Philosophical Society's Museum, York. Originally figured with its valleys still filled by the peculiar Diestien matrix, which has since been removed. (See Quart. Journ. Geol. Soc., 1870, vol. xxvi, p. 507, pl. xxxiv, figs. 1 and 2.) Drawn of the natural size.

II.—The Glaucophane Gabbro of Pegli, North Italy.

By John Parkinson, F.G.S.

(PLATE XII.)

In a paper published some years back on the Tuscan and Ligurian Serpentines[2] Professor Bonney has noticed incidentally the occurrence of glaucophane in the gabbro associated with these rocks at Pegli, a village to the west of Genoa; and later added a rather fuller description towards the end of his paper[3] on "The Glaucophane Eclogite of the Val d'Aoste." Last year I spent a few days at Pegli for the purpose of examining the rocks at the village and in its neighbourhood, when I found the gabbro in some abundance, in consequence, as I think, of blasting for road-making. The specimens then collected have disclosed on examination a few points of interest which may not, I hope, be deemed a superfluous addition to the accounts already published. Those have been rather numerous. Dr. G. H. Williams has briefly described[4] a glaucophane containing rock from this neighbourhood, which he calls an amphibolite, and, later, Stefani[5] has called in question the propriety of the term

[1] Fragments of molars showing this typical fold have been recorded by me from Suffolk: Quart. Journ. Geol. Soc., 1870.

[2] Geol. Mag., Dec. II, Vol. VI (1879), p. 363.

[3] Min. Mag., vol. vii (1885–7), p. 5.

[4] Neues Jahrb. für Min. Geol., 1882, Bd. ii, p. 201.

[5] Boll. d. Soc. Geol. Ital., vol. vi (1887), p. 233.

FIG. 1.

× about 8½ times.

FIG. 2.

× about 75 times.

Glaucophane Gabbro of Pegli, North Italy.

glaucophane gabbro for a rock "near Pegli." This he describes as being distinctly stratified, and as being characterized by possessing glaucophane in place of typical hornblende. Besides glaucophane the rock is said to contain plagioclase, commonly titanite or pyrites, and rarely quartz.

It is also worthy of remark that more recently a description has been published by Chelussi[1] of two glaucophane-bearing rocks from the island of Giglio, situated to the west of the Orbetello peninsula and not far south of the island of Elba. One of these is a gabbro in which a diallage alteration takes place, resulting in the formation of glaucophane, the dominant characteristic of the Pegli rock. The other he calls a diorite, and compares with the rock Professor Bonney and Professor Stefani have already noticed. He thinks that from the smallness of the constituents the rock might almost be called a microdiorite, but that it approaches an amphibolite in its rather schistose structure and in the abundance of its hornblende. The glaucophane is present either as flakes, as irregular tabular crystals, or as needles and fibres. The fact that these rocks present many points of resemblance to the one near Genoa is, I think, of interest. Both rocks are decomposed, that from Pegli the more so especially as regards the felspars, but the likeness is sufficiently striking.

M. Lacroix, in his work "Mineralogie de la France et de ses Colonies" (vol. i, p. 706), describes many instances in which secondary glaucophane results from the change—often a very complete one—effected in various gabbros. Speaking of those rocks from Villarodin, near Modane, he remarks that the production of glaucophane has been brought about by the usual methods of uralitization, and that it may also be found in the midst of an aggregate of epidote, albite, and calcite, which has resulted from the saussuritization of the felspars. The occurrence of diallage as the parent of glaucophane is apparently by no means uncommon, and has been recorded several times in addition to the instances which have been already mentioned. Professor Bonney, speaking of glaucophane crystals from the neighbourhood of Zermatt,[2] remarks that "their structure suggests to me the possibility of the replacement of a diallage"; Mr. Rutley,[3] in describing some glaucophane epidote schists from M. Viso, remarks that the rock contains a little diallage "sometimes enclosing numerous crystals of glaucophane"; and Professor Kotō,[4] writing on glaucophane from Japan, describes many rocks in which this mineral is secondarily developed from—as he believes—diallage; one of these he compares with the Pegli rock as regards the character of its groundmass. This author thinks the very finely fibrous glaucophane often present in these rocks is crocidolite, but owing to the nature of the mineral is unable to apply a decisive test. In describing the rock from the Val Chisone[5]

[1] Atti R. Acc. Lincei, ser. v, Rendic. iv (1895), p. 466.
[2] Min. Mag., vol. vii, p. 7.
[3] Quart. Journ. Geol. Soc., vol. xlv, p. 60.
[4] Journ. Coll. Sci. Imp. Univ. Tōkyō, vol. i (1886), pt. 1; also Summary. Neues Jahrb. für Min. Geol., 1889, Bd. i, p. 36.
[5] Min. Mag., vol. vii, pp. 191–3.

Professor Bonney considers the probability that it had once been a dolerite, perhaps ophitic, the glaucophane resulting from the "molecular rearrangement of the constituents of an aluminous augite and labradorite."

Description.—The rock at Pegli is exposed at the western end of the village, on the beach and under the houses built out seawards from the left of the road. Macroscopically it is a dark rock, very tough, and usually without conspicuous felspars, though occasionally their remains give the rock the common black and white mottled look of an ordinary fairly coarse gabbro. The ferromagnesian constituent is much developed in the majority of cases, and in this the slaty-blue tinge of the glaucophane is conspicuous. In sections it is seen to be a diallage felspar rock usually altered throughout by secondary changes, and showing much glaucophane. In almost all cases it is clear that the diallage has contributed largely to the formation of the glaucophane, and the term glaucophane gabbro is therefore entirely applicable. The more usual change results in a well-marked rim to the altering diallage, accompanied by more or less definite flakes and scales of the same mineral in the body of the parent crystal. In some cases the flakes are grouped irregularly without semblance of orientation; usually, however, the relation is a definite one, flakes and films of glaucophane are scattered throughout the parent crystal, irregularly outlined and blotchily coloured, but replacing the diallage in the same crystallographic sense. In a few instances the diallage is changing into both glaucophane and a brown hornblende; when this takes place the two replacing minerals are intimately associated together. This arrangement of glaucophane and hornblende replacing diallage very closely resembles that described and figured by Lacroix in an euphotide from Villarodin.[1] The absorption along $\mathfrak{c}$ appears to me to be frequently greater than in either the island of Syra or in the Île de Groix rocks, for an examination of slides from which localities I am indebted to the kindness of Professor Bonney. This is the variety which Lacroix terms "glaucophane foncée," characterized by the following pleochroism: $\mathfrak{c}$, dark Prussian blue; $\mathfrak{b}$, violet blue; $\mathfrak{a}$, light greenish yellow. This differs by its pleochroism from his "glaucophane normale," which has $\mathfrak{c}$ lavender blue, $\mathfrak{b}$ purple blue, $\mathfrak{a}$ colourless or yellowish. In the Pegli rock the two are closely associated, and replace one another indifferently; the "glaucophane foncée" may be either fibrous or platy in habit.

The glaucophane rim usually found bordering the diallage is nearly always more regular on its internal than on its external edge, as though the formation of the replacing mineral had been continued outwards as irregular root-like films and streaks into the surrounding material, often extending for a considerable distance with a lighter shade of blue. In some instances the irregular edge is practically identical with the "flame-like forms" assumed by the blue amphibole edging added to common hornblende which have been described by W. Cross[2] from Colorado. By the production of flakes of

[1] Min. de la Fr. et de ses Colon., vol. i, p. 581, fig. 14.
[2] Amer. Journ. Sci., T.S., vol. xxxix (1890), p. 368, fig. 2.

glaucophane in the body of the diallage, an entire replacement by the former mineral is obtained; the characteristic diallage striation remaining even when scarcely any trace of the original mineral can be seen. The formation of closely massed flakes of glaucophane in cracks which crushing has caused in the diallage is also common. Professor Kotō has described many similar cases in the paper previously mentioned. The diallage passes directly into glaucophane. The dark, rather yellowish brown of the former mineral is lost in great measure with some abruptness, and the characters of the glaucophane assumed. Frequently it is crowded with granular enclosures which are most probably an excretion or residuum from the manufacture of the secondary mineral. They occur abundantly in those flakes which can be certainly demonstrated to have arisen from the diallage, rather than in those films and scales whose origin from the pyroxenic mineral cannot be so readily determined. They are entirely absent from the diallage in its freshest condition, and when the glaucophane is traversed by cracks now filled by secondary minerals, the granular mineral is absent; from which may be inferred that it does not form where the facilities for the removal of material are easy. The habit and high polarization tints strongly recall epidote, and it is most probable that the major part of the lime has been used up in this way. The rather high iron percentage of glaucophane makes it probable that most of this constituent present in the diallage would be used in the formation of the former mineral, and the presence of some quantity of zoisite with the epidote may be inferred therefrom. In some sections the glaucophane appears as a closely packed mass of flakes, straight or slightly wavy; which are arranged in groups or bundles with a slight tendency to a radial disposition, and not unmixed with actinolite or a kindred mineral. In one or two cases this glaucophane becomes minutely fibrous, and is then probably the same as the mineral Kotō has termed crocidolite, and which he believes to result from an alteration of the glaucophane. Here and there, but not commonly, in the Pegli gabbro the pleochroism is different to that of either normal or dark glaucophane, and is characterized by a blue-green or sea-green tint. The variety is platy or fibrous, the former paler in colour. The occurrence of the nearly allied species crocidolite on or near the north-western coast of Italy has been recorded by M. Lacroix[1] from Cape Argentario, near Orbetello, and from the island of Gorgona, to the west and a little to the south of Leghorn. That from the first locality is formed from diallage. M. Lacroix states that in his opinion many secondary blue hornblendes, described as glaucophane, are really crocidolite. Such an instance may, he thinks, be found in the blue amphibole partly replacing pyroxene, which has been described as glaucophane from a rock occurring in South Central Spain.[2]

The same author[3] has noticed a variety of glaucophane distinguished

[1] Bull. de la Soc. Min. de Fr., vol. xiii (1890), p. 10.
[2] Comp. Rend., vol. cii (1886), p. 640.
[3] Min. de la Fr., vol. i, p. 700.

from the normal mineral by its higher extinction angle, and at the same time by a slight difference of pleochroism, consisting principally in a greenish shade parallel to c. This he considers intermediate to some extent between normal glaucophane and hornblendes poor in alkalis. Extinction angles high for glaucophane, up to (say) 20° or even higher, are found in the Pegli rock. In many instances the general appearance of the mineral and its connection with definite remnants of diallage indicate that the high extinction is due to its derivation from a pyroxene, but the pleochroism scarcely agrees with that given by Lacroix. When the depth of coloration is irregular the extinction is irregular also, and not well defined in relation to the pleochroism.

It seems perfectly reasonable to suppose that a local deficiency of soda during the process of glaucophane manufacture would lead to the formation of an actinolite at such a point, and that the withdrawal of the same constituent from established glaucophane would produce the commoner form of hornblende by an inverse process. The considerable proportion of alumina which glaucophane usually contains appears a difficulty to the understanding of this change to actinolite; but Foullon[1] has published an analysis of a very fibrous soda-bearing hornblende — practically identical with glaucophane — which he terms Rhodusite, and in which the alumina percentage is about half per cent. Unfortunately it is impossible to isolate the glaucophane from the Pegli rock, and an analysis cannot therefore be prepared. Judging from the literature of the subject, however, actinolite appears to be by no means the only mineral into which glaucophane may pass. Dr. Barrois, describing[2] the glaucophane rocks of the Île de Groix, mentions the change of the characteristic constituent into smaragdite; the change into crocidolite has been discussed by Kotō as mentioned above; Williams, in the paper already cited, has described a possible change to arfvedsonite in pebbles from Gesmagnano, and Columba[3] has recently proved an alteration into chlorite.

The character of the groundmass has been already briefly described by Professor Bonney. Its most remarkable point is the absolute reconstitution of the original felspar, so that no hard and fast line can be drawn between the altering diallage and the material in which it is set. This varies greatly from place to place. Prolongations of the glaucophane, detached scales and flakes of the same mineral, associated with abundant similar flakes of a rather dark-green and inert mineral, in many cases no doubt actinolite, though occasionally perhaps chlorite, lie scattered in a water-clear substance, which resolves itself, under crossed nicols, into a fine mosaic. Most of this is no doubt a secondary felspar, but it is only in very rare instances that the characteristic twinning places this beyond doubt. By diminution in the amount of actinolite and glaucophane, and by the appearance of a rather dirty and granular

[1] Sitz. Akad. Wien, vol. 100 (1891), pp. 169–171.
[2] Soc. Géol. du Nord, t. xi (1883–4), p. 50.
[3] Atti R. Accad. Sci. Torino, vol. xxix (1894), p. 416.

epidote, with perhaps occasionally zoisite, the character of the altered groundmass changes. White mica is occasionally met with in some quantity, at times constituting, in small closely felted flakes, nearly all the groundmass of the rock; at others including many of the colourless grains. Here and there the alteration has given rise to a brownish-black mineral, far from clear, but showing occasionally very roughly hexagonal and prismatic outlines, which from the extinction is probably monoclinic. No definite cleavage can be observed, and under a fairly high power the structure appears to be finely granular. This may be a somewhat unusual form of epidote. Characteristically it occurs in groups of close-packed grains, about ·1 mm. across, often pear-shaped in outline; but in many cases the dimensions of the individuals scarcely become apparent till the nicols are crossed. The polarization colours are low, but the impure character of the mineral may have something to do with this. An earlier stage in the life-history of this mineral is found in the indefinite clouds and patches of an opaque substance lying round and indistinguishable from the more definite grains. As a rule crossing the nicols discloses the presence of obscure individuals, but here and there even these are hard to discern; there is merely an even dissemination of blackish material with very little double refraction. In one or two slides long prismatic or acicular crystals (average size about ·12 mm. by ·016 mm.) are arranged in twos and threes in diverging groups; and locally are rather abundant. Those I think may possibly be actinolite. Their opaque appearance, due apparently to the amount of impurities contained, as well as their small size, renders an exact determination impossible. They are irregularly terminated, rather fibrous in structure, with a greenish tinge, and with weak double refraction. They are set as a rule in a closely felted mass of white mica, so that here, as in several other places, the more acid or felspathic element usually produced during the decomposition of one of the more basic felspars seems absent.

One or two accessory constituents remain to be noticed. In a few slides apatite occurs in some quantity, either in well-formed idiomorphic crystals—cross sections sometimes measure ·75 mm. across—or in groups of irregular grains. Such allotriomorphic outlines as these grains possess, together with a rather dusty appearance which the mineral has, were unlike the usual habit of apatite; and I am indebted to Mr. J. J. H. Teall, F.R.S., who very kindly examined the slide and made the determination for me, suggesting at the same time the usual molybdate test as a ready means of settling the point definitely. This was done, and since the usual yellow precipitate followed there can be no doubt that the mineral is really apatite. Pyrites is present in some quantity, sometimes showing idiomorphic outlines, and there is in addition a considerable quantity of ilmenite altered in greater or less degree to leucoxene. The sp. gr. of the gabbro as determined by a Walker's balance is 3·129. This is the mean of determinations made on several specimens, the results agreeing closely with one another. The sp. gr. of the more felspathic variety is 2·977.

Finally, I wish to express my indebtedness to Professor Bonney for the help he has afforded me in the preparation of these notes.

DESCRIPTION OF PLATE XII.

FIG. 1.—General structure of glaucophane gabbro. To the right and below the centre are three crystals of diallage, showing the dark border of glaucophane, and, internally, dark patches of the same mineral. In reality nearly all the mineral is converted into glaucophane; the orthopinacoidal striation of the diallage is seen with difficulty in the figure. Above these crystals is much of a pale-green chloritic mineral with flakes of glaucophane, and in places with a border of the same. In it can be seen large black patches of pyrites, and others of a water-clear substance. Near the centre and left-hand top corner are good examples of the altered groundmass. × about 8½.

FIG. 2.—The glaucophane fringe surrounding a crystal of diallage, itself almost entirely altered to the same mineral. The extension of the fringe into the altered groundmass of the rock is seen to the left of the figure. × about 75.

III.—OBSERVATIONS ON SOME BRITISH CRETACEOUS MADREPORARIA, WITH THE DESCRIPTION OF TWO NEW SPECIES.

By ROBERT F. TOMES, F.G.S.

(PLATE XIII.)

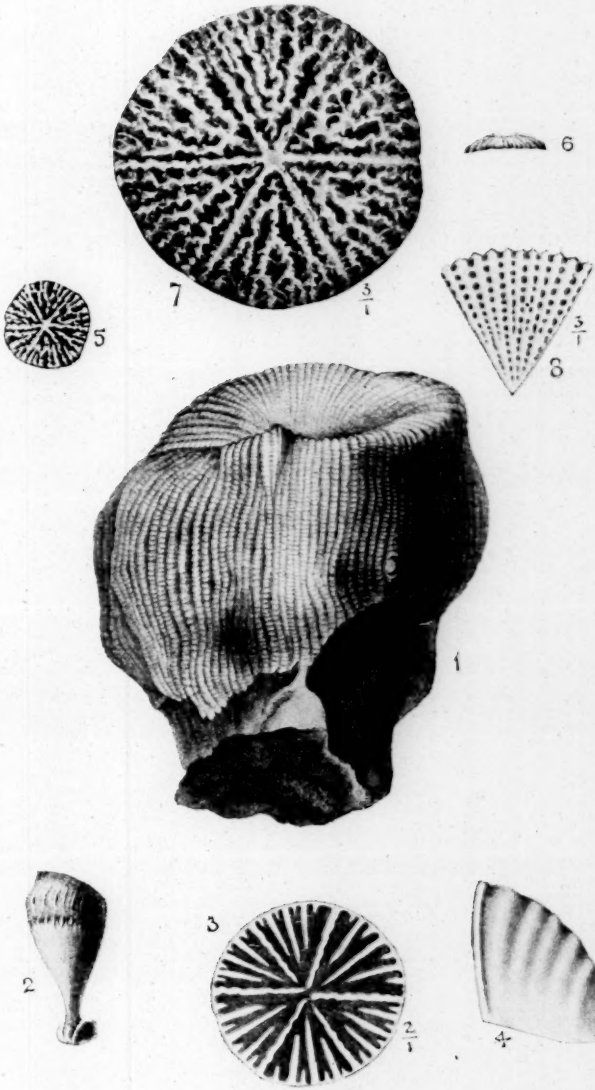
ON the 24th of June, 1885, a paper by me, entitled "Observations on some imperfectly known Madreporaria from the Cretaceous Formation of England," was read at a meeting of the Geological Society which, encountering an adverse report from the referee, was with the consent of the Council, withdrawn by me, and published verbatim in the GEOLOGICAL MAGAZINE of the same year (Dec. III, Vol. II, pp. 541–563, Pl. XIV), 1885. The present communication is a continuation as well as a correction of the former one, which has become necessary from the acquisition of additional material. Before, however, going into particulars respecting the several species to be referred to here, I wish to offer a few remarks on certain of the genera.

Bathycyathus has been merged by the late Professor Duncan into *Caryophyllia*, but I am not at present prepared to accept that alteration, a very strict revision of the latter genus being, according to my view, quite necessary before such forms as *Bathycyathus Sowerbyi* are placed in it.

Cœlosmilia, as we learn from the same authority, is a subgenus only of *Trochosmilia*; "the main distinction between the two types only relates to the amount of endotheca."[1] While, however, expressing himself as above, Professor Duncan did not fail to note that *Cœlosmilia* includes "a number of species with a well-defined facies." It is that well-defined facies, with certain important peculiarities in the development of the septa themselves, into the consideration of which I do not here enter, that induces me to retain, at any rate for the present, the genus *Cœlosmilia* as defined by MM. Milne Edwards and Haime.

Although no species of *Smilotrochus* is admitted in the present paper, it is desirable that a few remarks should be made respecting

[1] Revision of the Families and Genera, 1884, p. 52.



R. F. Tomes del. S. Austin & Sons imp.

British Cretaceous Madreporaria.

the genus. It was created in 1851 by MM. Milne Edwards and Haime[1] for the reception of a single British species from the Greensand of Blackdown, *Smilotrochus tuberosus*, which they had already placed, though with doubt, in the genus *Trochosmilia*.[2] Afterwards, that is to say in 1857,[3] they brought two other species into the genus, one of them from the Farringdon Greensand, *Smilotrochus Austeni*, and the other, *S. Hagenowi*, from the White Chalk of Maestricht.

The "Introduction" of Dr. de Fromentel, which appeared in 1858–61, made no addition to or alteration of either genus or species; but in 1869 and 1870[4] Professor Duncan, while including the two British species above mentioned, added five others to the genus, making in all seven British species. In 1885 the present writer[5] described and figured an eighth; but both it and all those added by Professor Duncan have now been found to appertain to other genera. Moreover, *Smilotrochus tuberosus*, the very species on which the genus was founded, is in the present communication shown to be a *Placosmilia*. As a genus, therefore, *Smilotrochus* now rests on two species, *S. Austeni* and *S. Hagenowi*. Of the former so little is known that a re-examination is most desirable, and all the more so as so many simple Cretaceous corals have proved on close examination to appertain to genera characterized by the presence of a columella or pali, or of both.

Before entering into the details of the several species, I wish to record my indebtedness to Dr. Blackmore, of Salisbury, by whose kindness I have recently examined a collection of corals from the Chalk of that neighbourhood, some of which will shortly be mentioned. He has also favoured me with a section of the Salisbury Chalk, which enables me to place the several species in their precise position in the formation, and also to give their relative frequency, as follows:—

	Feet.	
1. Zone of *Belemnitella mucronata*, the highest beds, corresponding to the beds of Norfolk and Dorchester.	80	*Onchotrochus serpentinus.* *Cœlosmilia laxa.* *Parasmilia centralis.* ——— *Mantelli.* *Axogaster cretacea.*
2. Zone of *Actinocamax quadrata*, chiefly exposed at East and West Harnham, and worked for whitening.	170	*Parasmilia centralis.* ——— *Mantelli.* ——— *Gravensis.* *Cœlosmilia laxa.* ——— *regularis.* *Diblasus Gravensis.* *Stephanophyllia numismalis.* *Axogaster cretacea.*
3. Zone of *Marsupites*	230	*Caryophyllia cylindracea.* *Parasmilia centralis.* *Axogaster cretacea.*
4. Zone of *Micraster cor-anguinum*	250	*Caryophyllia cylindracea.* *Parasmilia centralis.* ——— *serpentina.*

[1] Pol. Foss. Terr. Paleoz., 1851, p. 29.
[2] Brit. Fos. Cor., 1851, p. 58, pl. x, fig. 2.
[3] Hist. Nat. Cor., t. ii (1857), p. 71.
[4] Supp. Brit. Fos. Cor., pt. ii, No. 1, p. 19, and pt. ii, No. 2, p. 36 (1869–70).
[5] Geol. Mag., December, 1885.

The comparative frequency of some of the species is as follows:—

Parasmilia centralis	200
——— *Gravensis*	4
——— *Mantelli*	38
Cœlosmilia (both forms)	64
Caryophyllia cylindracea	12

The small Madreporaria of the Gault are so beautifully preserved externally, and, from the cavity of the calice being almost always obscured, are so difficult to examine internally, that a few words on the best method of investigating their inner parts will not be out of place. To begin with, all idea of washing out the calice may be at once dismissed as altogether impracticable. Then there is the breaking up of the corallum in the hope that a fortunate fracture may reveal what lies in the bottom of the calice, which sometimes proves successful. But it is very uncertain work, and the following method of examination may with advantage be adopted in its stead.

Take a spoonful of fine plaster of Paris and well mix with it a sufficient quantity of lamp-black to make it of a pale slate colour; add water until it is of the consistency of thick cream. With this fill a small box—an ordinary pill-box will do very well—and place the coral, which must have been carefully removed from its matrix of Gault, vertically in it, with the calice only exposed. It should then be allowed not only to set, but to become thoroughly dry, when some thin gum-water must be dropped into the calice, and again be allowed time to dry. The whole can then be rubbed down until the bottom of the calice is exposed. I have found fine sand-paper, kept flat by attachment to a strip of wood, a good thing to rub down with, but great care must be taken to keep all the dust raised by the operation blown away as fast as made. A common blowpipe will do that quite successfully. If there is no destructive pyrites or hard phosphate present in the calice, the coral will then be seen in section, and present the appearance of a well-defined white figure on a dark ground, and the presence or absence of a columella or pali can be at once determined. It is the nearly white colour of the substance of the coral itself which renders desirable the mixture of lamp-black with the plaster, which, with a little care, will when dry have very nearly the same colour as the Gault matrix.

BATHYCYATHUS SOWERBYI, Edw. & Haime: Brit. Fos. Cor., 1850, p. 67, pl. ii, fig. 2.

Smilotrochus elongatus, Dunc. (in part): Supp. Brit. Fos. Cor., 1869, pt. ii, No. 1, p. 19, pl. vi, figs. 1–6.

Trochocyathus conulus, Jukes-Browne (not Phillips): Quart. Journ. Geol. Soc., 1875, vol. xxxi, p. 303, pl. xiv, figs. 14–16.

After a most painstaking examination I am fully satisfied that all the specimens of the so-called *Smilotrochus elongatus* from the Coprolite Bed of the Cambridge Greensand must be referred to *Bathycyathus Sowerbyi*, and not, as was supposed by Mr. Jukes-Browne, to *Trochocyathus conulus*, and my reasons for arriving at that conclusion are as follows:—The broad and spreading foot which is so well shown in Mr. Jukes-Browne's figure (fig. 14)

is precisely that of *Bathycyathus*, and is not characteristic of *Trochocyathus conulus*. The comparatively feeble development of the columella is also evidence in the same direction; but what is most conclusive is the fact that unquestionable specimens of *Bathycyathus* from the Folkestone Gault, when much worn and the wall and spreading foot partially or wholly absent, are undistinguishable from the Cambridge specimens, which, it should be remembered, are very rarely anything more than casts of the interior. It was Mr. Jukes-Browne, however, who pointed out that the Cambridge coral could no longer be retained in the genus *Smilotrochus*, and he subsequently showed that the so-called *Smilotrochus angulatus* must also be removed from that genus. Of the latter so-called species I can only say that I can follow Mr. Jukes-Browne in that conclusion, having observed in some of the Cambridge specimens the evidence of a small columella near the lower end of the coral.

Cyclocyathus Fittoni, Edw. & Haime.

Micrabacia Fittoni, Dunc.: Supp. Brit. Fos. Cor., 1870, pt. ii, No. 2, p. 37, pl. xiv, figs. 6–9.

The specimen which I mentioned in my former paper as having been received from Dr. S. P. Woodward still retains its label in his handwriting: "*Cyclocyathus Fittoni*: Gault, Folkestone." It came to me in 1862, and has never been out of my hands, and every endeavour to obtain another specimen has proved futile.

The description and figure of *Micrabacia Fittoni* by Professor Duncan appeared in 1870,[1] but it is worthy of remark that in 1884, a year before the date of my paper,[2] he expressed some doubt as to the generic relationship of the type-specimen. There can be no doubt from the very close resemblance between my specimen and the figure of *Micrabacia Fittoni* as to the specific identity of the two specimens; and that there is a columella and pali in the one is beyond all doubt, while in the other the whole of the centre was so much obscured by extraneous matter that it is impossible to say what there may have been. The occurrence of only two specimens in the Folkestone Gault indicates the rarity of this form, whether we regard it as a variety of *Cyclocyathus Fittoni* or a distinct species.

Trochocyathus conulus, Phillips, sp.

Caryophyllia conulus: Phill. Ill. Geol. Yorks., 2nd ed., 1835, pl. ii, fig. 1.

Turbinolia conulus: Mich. Icon. Zooph., 1840, p. 1, pl. i, fig. 12.

Trochocyathus conulus, Edw. & Haime: Brit. Fos. Cor., 1850, p. 63, pl. ii, fig. 5.

Smilotrochus elongatus, Duncan: Supp. Brit. Fos. Cor., pt. ii, No. 2, p. 36, pl. xii, figs. 10–16; pl. xiii, figs. 10–12. (Not Jukes-Browne: Quart. Journ. Geol. Soc., 1875, vol. xxxi, p. 303, pl. xiv, figs. 14–16.)

Smilotrochus cylindricus, Duncan: Supp. Brit. Fos. Cor., 1870, pt. ii, No. 2, p. 36, pl. xiv, fig. 16.

[1] Quart. Journ. Geol. Soc., 1884, p. 565.
[2] Geol. Mag., 1885.

The name of *Caryophyllia conulus* was given by Phillips in 1835 to a coral found in the Speeton Clay of Yorkshire; and having obtained a number of specimens from that locality which are obviously identical with the coral figured by Phillips, I have been enabled to compare and identify these with specimens from the Folkestone Gault, and to clear up the synonymy of the species.

Trochocyathus conulus, as I now restrict it, never attains to the size of the specimens from the Cambridge Greensand described by Professor Duncan as *Smilotrochus elongata*, which latter, it should be remembered, are only casts of the interior, and are not nearly so large as the perfect coral would be. The figures of *Trochocyathus conulus* given by Phillips and Michelin represent very full-sized examples, but most of the specimens from both Speeton and Folkestone are smaller and less regular in form.

Michelin gives two figures of this species, one being of an adherent coral and the other of one that was free. The latter is a good representation of *Trochocyathus conulus*, but the former is more like *T. Wiltshirei* than *T. conulus*, both of which species are found associated at Folkestone. In none of the specimens from Speeton which I have seen is there an adherent foot.

The more elongated corals from the Gault at Folkestone described and figured by Professor Duncan as *Smilotrochus cylindricus* occur also at Speeton They have both columella and pali, and are certainly *Trochocyathi*—indeed, nothing more than elongated individuals of *Trochocyathus conulus*.

TROCHOCYATHUS WILTSHIREI, Duncan.

Trochocyathus Wiltshirei, Dunc.: Supp. Brit. Fos. Cor., 1870, pt. ii, p. 34, pl. xiv, figs. 10–12.

Smilotrochus granulatus, Dunc.: loc. cit., p. 76, pl. xiv, fig. 17.

Since the appearance of my former paper in 1885 I have examined many specimens of this species, and while I am satisfied that it is a good one I am more than ever convinced that the so-called *Smilotrochus granulatus* is nothing more than the young form of it.

TROCHOCYATHUS? CALCARATUS, Tomes.

Smilotrochus calcaratus, Tomes: GEOL. MAG., 1885, p. 543.

Of this very peculiar species I can now say that its characters are by no means those of *Smilotrochus*. The ragged spines of the septa, which increase in size and prominence as they approach the fossula, obscure the latter part so much that examination is difficult, but they meet and blend in the centre of the calice, with what I have little doubt is a true but small columella. Moreover, in some of the better preserved calices there is a somewhat circular disposition of the spines around a centre, indicative of the presence of pali. And if there is both columella and a ring of pali, the species must be referred to the genus *Trochocyathus*.

Besides occurring in the Gault at Folkestone, the present species has been found in the Speeton Clay of Yorkshire, from which locality I have a well-preserved specimen, in which there are certainly evidences of the presence of a columella.

CERATOTROCHUS INSIGNIS, Duncan, sp.

Smilotrochus insignis, Dunc. : Supp. Brit. Fos. Cor., 1870, pt. ii, No. 2, p. 37, pl. xii, fig. 17 ; pl. xiv, fig. 18.

There is considerable doubt as to the generic place of this small species, but that it cannot retain its position in the genus *Smilotrochus* is most certain. In addition to the existence of a very distinct columella it is probable that there is a ring of pali, in which case it is a *Trochocyathus*. In fractured specimens there is to be seen surrounding the large columella a kind of outer ring having much the appearance of adherent and styliform pali, which, however, have a height corresponding with that of the columella, and may therefore be a part of it.

DIBLASUS, sp.

By the kindness of Mr. Jukes-Browne I have examined some much worn specimens of *Diblasus* from the Coprolite Bed of the Cambridge Greensand, and compared them with examples of *Diblasus Gravensis* from the Chalk of Gravesend. They are certainly specifically distinct, the costæ being small—only half the size of those of *D. Gravensis* — and much more regular in size and prominence. In none of the specimens are there any calices, and I refrain from further description.

PLACOSMILIA TUBEROSA, Edw. & Haime, sp.

Turbinolia compressa, Morris : Cat. Brit. Fos., 1843, p. 46.
Trochosmilia ?, tuberosa, Edw. & Haime : Brit. Fos. Cor., 1850, p. 58, pl. x, fig. 2.
Trochosmilia tuberosa, Morris : Cat. Brit. Fos., 2nd ed., 1854, p. 68.
Smilotrochus tuberosa, Edw. & Haime : Pol. Fos. Paleoz., 1851, p. 29 ; Hist. Nat. Cor., 1857, tom. ii, p. 71.
Placosmilia cuneiformis ?, Duncan (not Edw. & Haime) : Supp. Brit. Fos. Cor., 1869, pt. ii, No. 1, p. 27, pl. x, figs. 1–5.

A single specimen from the Greensand of Blackdown, which formed part of the collection of my late friend Dr. Wright, and is now before me, has the peculiar swellings near the foot which gave to the species its specific name ; and although they are not quite so conspicuous as in the figures given by MM. Milne Edwards and Haime, there is no doubt as to the species.

The Blackdown specimen has a deep-seated and not very strongly formed columella, extending the whole length of the fossula, which is more than half the length of the calice, and its presence removes the species at once into the genus *Placosmilia*, and confirms its specific identity with the small deltoid corals from the Haldon Greensand regarded by Professor Duncan as the *Placosmilia cuneiformis* of MM. Milne Edwards and Haime ; a wholly distinct and dissimilar species occurring in the Gosau deposits, as I have determined by the comparison of undoubted specimens from the last-named locality.

The Haldon specimens correspond very closely in general size and form with the one from Blackdown, and especially in the length

and degree of development of the lamelliform columella, but differ in having the tuberosities at the foot only feebly indicated, and the ribs on the sides of the septa more strongly marked. I have examined a considerable number of these small *Placosmiliæ* from Haldon, but they are merely siliceous casts, and so badly preserved that had I not the advantage of a well-preserved specimen from Blackdown for comparison, I should hesitate to speak decisively of them, excepting to determine with absolute certainty their distinction from the Gosau specimens of *Placosmilia cuneiformis*. The latter are perfectly distinct from the Blackdown and Haldon specimens.

Trochosmilia sulcata, Edw. & Haime: Brit. Fos. Cor., 1850, p. 68, pl. ii, fig. 6.

I notice this species only to record its great rarity, one specimen alone amongst several hundreds from the Gault at Folkestone having reached me; and I may make the same observation respecting the extremely pretty *Leptocyathus gracilis*,[1] a single specimen being all that has appeared.

Parasmilia granulata, Duncan: Supp. Brit. Fos. Cor., 1869, pt. ii, No. 1, p. 13, pl. vi, figs. 5–8.

The present species was founded on one or more specimens in the Dixon Collection, but as no indication of locality has been made known, I take the opportunity of recording some examples which were in the collection of Dr. Wright and came to me labelled in his handwriting, "*Monocarya centralis*, W. C. Brighton." They accord well with the figures and description given by Professor Duncan, but one of them is of greater size than the types, having a height of 1 inch 4 lines and a diameter of calice a little exceeding 10 lines. It has the largest calice of any British *Parasmilia* I have yet seen.

Parasmilia Mantelli, Edw. & Haime: Brit. Fos. Cor., 1850, p. 49, pl. viii, fig. 2; Hist. Nat. Cor., 1857, tom. ii, p. 173.

The original describers of this species had access to one specimen only (from Bromley in Kent) when diagnosing the species, and Professor Duncan does not appear to have seen a single specimen even, but was of opinion that it was only a variety of *Parasmilia Gravesana*, which he reduced to the rank of a subspecies. By the kindness of Dr. Blackmore, of Salisbury, who has favoured me with a number of *Parasmiliæ* from the Chalk near that town, amongst which are several specimens of *Parasmilia Mantelli*, I can without hesitation restore the species to its former place. There can be no doubt as to its distinctness from *Parasmilia centralis* and *P. Gravesana*, and, indeed, from all the other British species of the genus; but I must make an addition to the otherwise very exact description of MM. Milne Edwards and Haime, and note the existence of a very large and rather elaborately developed columella, which attains in one specimen to quite one-third of the diameter of the calice.

[1] Duncan: "Supp. Brit. Foss. Cor.," pt. ii (1870), No. 2, p. 34, pl. xiii, figs. 5–8.

CŒLOSMILIA REGULARIS, sp. nov. Plate XIII, Figs, 2, 3, 4.

The corallum is small, turbinate, straight or a little curved, and attached by a very small foot, and there are distinct but not prominent annular swellings indicating periods of growth. The costæ are very indistinct, almost obsolete at the foot, but more defined near the calice. They are sub-equal, and alternately finely granulated and papillated.

The calice is symmetrical, circular or a little ovoid, and rather deep; the margin well defined, thin, and prominent, and the fossula small, deep, and a little elongated.

There are four cycles of septa in six systems; they are straight in their entire length, regular, not exsert, and their margins present a regular curvature from the wall downward into the fossula. Those of the first cycle almost meet in the centre of the visceral cavity, and are undulating in the direction of a horizontal line across them from the wall to the fossula. The undulations form broad, flattened, vertical ridges and furrows on the sides of the septa; the ridge on one side corresponding with the furrows on the other. The septa of the second cycle are three-fourths the length of the primary ones, and those of the third are a little more than half the length of those of the first cycle, while the septa forming the fourth are short, but vary considerably in different calices.

	in.	lines.
Height of the corallum	1	0
Diameter of the calice	0	6½

A larger specimen, showing periods of growth, has a length of 1 inch 9 lines, but has a calice of no larger dimensions than that given above.

The present species may be readily distinguished from all the other British species by the great regularity in the form of the calice, and in the development of the septa, as well as by the number of the cycles, and by the length of the septa forming the fourth cycle.

Hab.—The Upper Chalk of East and West Harnham, Salisbury, and the Upper Chalk of Brighton.

CŒLOSMILIA LAXA, Edw. & Haime.

This was the only British species of the genus accessible to MM. Milne Edwards and Haime when they wrote their history of British fossil corals, and of it they observe, "the septa are very unequally developed, broad, very exsert," and "those of the first and second cycla (*sic*) united along the lower part of their inner edge." In all the specimens from the Norwich Chalk which I have seen that irregularity is so remarkable that I have wholly failed to define the cycles, and have been obliged to satisfy myself by merely counting the septa. Including those which are merely rudimentary, I find in the largest corallum 68 septa, or four cycles, and 20 septa of the fifth cycle. In another having a calice only a little smaller there are 43 septa only. A third specimen has 44 septa. A fourth specimen, with a calice much reduced in size by recent rejuvenescence, has only 32 septa. Other specimens which I have examined have only

confirmed the great irregularity of septal development in the genus *Cœlosmilia*, in so far as *C. laxa* is concerned; and as the same thing has been noticed in *C. poculum*, *C. Fanjasi*, and *C. punctata* by MM. Milne Edwards and Haime, and in *C. Woodwardi* by Professor Duncan, we are justified in regarding it as having more than specific value, and as, I think, of more than subgeneric significance.

Of the Jurassic representatives of the genus *Cœlosmilia* reputed to have been found in the Nattheim Oolite, I am unable to speak.

RHIZANGIA MAMMILIFORMIS, Dunc., sp.

Podoseris mammiliformis, Dunc.: Supp. Brit. Fos. Cor., 1869, pt. ii, No. 1, p. 25, pl. ix, figs. 2–15.

I have examined several other specimens of this coral since the appearance of my paper in 1885, in which the stolon connecting the corallites is well preserved and obvious. I regret, however, that the opportunity has not occurred for examining any of the earlier known species of *Rhizangia* by means of sections, and ascertaining whether their septa have a pseudo-synapticular growth or not. There is no doubt whatever that the present species has septa which do not differ materially in structure from those of *Thamnastræa* and that there are also tabular dissepiments between them.

Of the second species, *Rhizangia elongata*, there is great doubt respecting its specific distinction. The taller the specimen, the more irregular is the outline; the smaller and more deformed the calice, the more abnormal is the cycle of septa. In fact, the elevated specimens present much the appearance often seen in other simple forms, namely, an abnormal and excessive growth, just what is not uncommon in certain species of *Montlivaltia*. *Rhizangia elongata* is at best a doubtful species.

LEPTOPHYLLIA CLAVATA, Reuss.

Leptophyllia clavata, Reuss: Denk. der Wiener Akad. der Wiss., 1854, t. vii, p. 101, pl. vi, figs. 3–6.
Turbinoseris de Fromenteli, Dunc.: Supp. Brit. Fos. Cor., 1870, pt. ii, p. 42, pl. xv, figs. 13–18.
Leptophyllia Anglica, Tomes: GEOL. MAG., 1885, p. 551.

Continued investigation has made it quite obvious that the coral which Professor Duncan described as *Turbinoseris de Fromenteli*, and which I subsequently named *Leptophyllia Anglica*, is nothing more than the *Leptophyllia clavata* of Reuss, the very species on which the genus *Leptophyllia* was founded.

LEPTOPHYLLIA IRREGULARIS, Reuss. Plate XIII, Fig. 1.

Leptophyllia irregularis, Reuss: Denk. der Wiener Akad. der Wiss., 1854, t. vii, p. 101, pl. vi, figs. 2, 3.

One instance only of the occurrence of this fine species in this country has come to my knowledge. It was obtained by Mr. F. H. Butler from the Lower Greensand at Sandown, Isle of Wight, out of the same bed which has supplied the *Leptophyllia clavata*. I have compared the specimen, which is

a large one and in fine preservation, with specimens of *Leptophyllia irregularis* from Gosau, and find that, although it differs a little from them in having rather thicker septa and costæ, it corresponds in every other particular, and so closely that the identity of the species cannot be doubted.

STEPHANOPHYLLIA NUMISMALIS, sp. nov. Plate XIII, Figs. 5–8.

The corallum is subcircular and much depressed, the upper surface having but little convexity and the outer edge being very thin. The base is a little concave. The basal wall is much perforated, much more so than in *Stephanophyllia Bowerbanki*, though less so than in *S. radiata*. The mural costæ are rather thicker than in *S. Bowerbanki*, and not so closely placed, the perforated spaces between them being nearly their own breadth. There are about fifteen perforations between each pair of costæ, but the number is somewhat variable. The costæ anastomose less freely than in *S. Bowerbanki*, and there are no indications of dissepiments between them.

The columella is rudimentary and depressed. The primary septa are straight, and pass into the columella; they are relatively rather thin and very irregular. The secondary septa are a little shorter than the primary ones; those forming the third cycle anastomose with the secondary ones near the columella, and the septa of the fourth cycle pass into those of the third at about half their length, while the septa constituting the fifth cycle join those of the fourth at a point approximately to their middle. There are some short and very irregularly developed septa of the sixth cycle anastomosing with the others. All the septa have margins which are excessively rugged (lacerated is the word used by MM. Milne Edwards and Haime), and the prominent angular points have the appearance of being twisted or bent in different directions.

Diameter of the corallum	...	...	5½ lines.
Height of the corallum	...	...	1 line.

One specimen only has been met with. It was obtained from the zone of *Actinocamax quadrata* in the Upper Chalk at East Harnham, near Salisbury, and is in the museum of that city. I am indebted to Dr. Blackmore for the opportunity of describing and figuring this rare and interesting species.

DESCRIPTION OF PLATE XIII.

FIG. 1. *Leptophyllia irregularis*, Reuss, the corallum, natural size.
,, 2. *Cœlosmilia regularis*, the corallum, natural size.
,, 3. ,, ,, the calice, magnified twice.
,, 4. ,, ,, a septum, magnified three times.
,, 5. *Stephanophyllia numismalis*, the corallum, natural size.
,, 6. ,, ,, the same, seen in profile.
,, 7. ,, ,, the calice, magnified three times.
,, 8. ,, ,, a portion of the basal wall showing the intercostal perforations, magnified three times.

IV.—Glaciated Valleys in the Faroes.

By Joseph Lomas, A.R.C.S., F.G.S.

THE interesting paper by Mr. Harker in the Geological Magazine of May, 1899, on "Glaciated Valleys in Skye," recalls to my mind many similar observations I made in the Faroes in the Summer of 1894. Not only are the valleys excavated out of homogeneous rocks, but the Faroes, like the Cuillins, had a glaciation of their own. It may be advisable, then, to call attention to some points which resemble those referred to by Mr. Harker, as well as others which are not seen in Skye.

The Faroes consist of a group of islands twenty-six in number. They have a trend approximately N.W.–S.E., and lie, with one or two exceptions, side by side, as if threaded on a line running N.E.–S.W. The islands are separated by long narrow fiords, and are evidently the result of erosion; no structural peculiarities in the great plateau of basalt suggest any other conclusion. A line drawn from Fuglo on the east to Myggenaes on the west gives the line of water-parting of the present day, as well as the ice-shed which obtained when the islands were glaciated. Soundings taken along the fiords show that they are shallow when the line crosses, and deepen N.W. and S.E. Into the fiords numerous cirques open on both sides.[1] Some of them are simple U-shaped valleys which have their floors above, at, or even below sea-level. Others descend in great steps towards the fiords, the curves embracing the tiers widening as they approach sea-level. Besides the simple forms, others are seen, which I have called compound or clustered cirques.[2] They consist of several U-shaped valleys which open into a common valley. We may compare them with leaves of shamrock, and they have evidently been determined by the courses of the rivers and their tributaries which eroded the plateau in Pre-Glacial times. The common valleys into which the tributary cirques open are not always straight, but trend towards the N.W. north of the line of ice-shed and towards the S.E. south of the line. This feature is particularly noticeable in the fiord which separates the two largest islands, Stromo and Ostero, from each other.

Extensive erosion has taken place since the Glacial period, for we find in some places a cluster of small islands, whose outlines show that at one time they formed part of one great cirque. Thus the remarkable island of Tindholm, and the Drangas associated with it, are all contained in one great basin-like curve. In many instances along the west and north coasts the cliffs are very lofty and imposing. They average over a thousand feet, and in places, e.g. Myling Head, present a sheer vertical wall over two thousand feet in height. When followed inland, however, the surface is often found to descend very rapidly into a great cirque, in some cases even

[1] See Glacialists' Magazine, June, 1895; and J. Geikie, T.R.S.E., vol. xxx, pt. 1, p. 218.

[2] Glacialists' Magazine, June, 1895.

below sea-level. A very fine example of this is seen near Tiornevig. Sailing northwards past the towering walls of Myling Head, we turn eastwards and at once come into the basin of a great cirque which falls in one grand curve two thousand feet. Myling Head, like many other parts of the coasts, is a mere narrow ridge of rock, separating the sea on one side from a cirque valley on the other.

It is hardly possible to enumerate all the cirque valleys which exist in the Faroes. They abound in all the larger islands, and tarns occupying true rock-basins are frequently seen on their floors.

NOTICES OF MEMOIRS.

The Parent-rock of the Diamond in South Africa. By Professor T. G. Bonney, D.Sc., LL.D., V.P.R.S.[1]

So much has been written on the occurrence of diamonds in South Africa, that a very few words may suffice as preface to this communication. References to many papers on the subject are given in "The Genesis and Matrix of the Diamond" (1897), by the late Professor H. Carvill Lewis,[2] and others have been published since that date.[3] It may suffice to say that the diamond, first discovered in 1867 in gravels on the Orange River, was found three years later in certain peculiar deposits, which occur locally in a region where the dominant rock is a dark shale, sometimes interbedded with hard grits, or associated with igneous rocks allied to basalt. These deposits occupy areas irregularly circular in outline, and bearing a general resemblance to volcanic necks. The diamantiferous material, near the surface, is soft, yellowish in colour, and obviously much decomposed; at a greater depth it assumes a dull greenish to bluish tint, and becomes harder. At the well-known De Beers Mine, near Kimberley, the works in 1898 had been carried to a depth of about 1,500 feet, and the diamantiferous material, for at least the last 100 yards, was not less hard than an ordinary limestone. It has a brecciated aspect, the dark, very minutely granular, matrix being composed mainly of serpentine (about four-fifths of the whole), and of a carbonate of lime (with some magnesia and a little iron). In this matrix are embedded grains of the following minerals: Olivine, enstatite, smaragdite, chrome-diopside (omphacite of some authors), a brown mica, garnet (mostly pyrope), but more than one variety observed, magnetite, chromite, ilmenite, with several other minerals much more sparsely distributed.

Rock fragments are also present, variable in size, but commonly not exceeding about an inch in diameter, as well as in quantity.

[1] Being a paper read before the Royal Society on June 1st, 1899.

[2] Edited by the present writer.

[3] Jules Garnier, Geol. Soc. South Africa Trans., 1897, p. 91; H. S. Harger, ibid., p. 124. See also W. G. Atherstone, ibid., 1896, p. 76; L. De Launay, Compt. Rend., vol. 125 (1897), p. 335. The last author, in "Les Diamants du Cap" (Paris, 1897), gives a very full account of the mines, but an even better one will be found in Max Bauer, "Edelsteinkunde" (Leipzig, 1896, p. 208).

These, occasionally, but not generally, are rather abundant. In some cases they are chips of the neighbouring black shale, but in others they are greyish-coloured with a somewhat porcelainised aspect. The latter are generally subangular in form and externally banded or bordered with a darker tint; crystalline rocks have also been noticed, though these appear to be far from common, such as granite, diorite, and varieties of eclogite.[1] As to the genesis of the diamond, more than one opinion has been expressed. Professor Lewis regarded the matrix as a porphyritic form of peridotite, once a lava, now serpentinised,[2] in which the diamond had been formed by the action of the molten rock on some carbonaceous material (probably the Karoo shale). Others regarded the matrix as a true breccia, comparing it with the agglomerates in volcanic rocks. But among the latter, some thought that the diamond had been produced *in sitû* by the action of steam or hot water in a subsequent solfataric stage of the volcano, while others (including myself) held that it had been formed, like the garnets, pyroxenes, etc., in some deep-seated holocrystalline mass which had been shattered by explosions.[3]

The specimens which I am about to describe were obtained at the Newlands Mines, West Griqualand; from 40 to 42 miles from Kimberley, almost due N.W. Here the workmen occasionally came across well-rounded boulder-like masses of rather coarsely crystalline rock, studded with garnets, which are sometimes about a foot in diameter. Specimens of these were found or obtained by Mr. G. Trubenbach, the London manager of the Newlands Diamond Mine Company, during a visit to the mines in 1897. His interest had already been aroused by picking up a specimen, presently to be noticed, in which some small diamonds occurred, very closely associated with a garnet; so the boulders were brought back by him to England. On careful examination a small diamond was detected on the surface of one of these. On breaking the boulder others were revealed. The most interesting fragment was sent by Mr. Trubenbach to Sir W. Crookes, who showed it to me. Examination with a hand lens convinced me that the rock could not be a concretion of the 'blue ground,' but was truly holocrystalline and allied to the eclogites. Sir W. Crookes generously waived his own claim to study the specimen, and obtained for me permission from Mr. Trubenbach to have slices cut from it. I gladly take this opportunity of expressing my gratitude to both gentlemen; to Sir W. Crookes for allowing me to carry out this interesting investigation, and to Mr. Trubenbach for his great liberality in placing at my disposal a considerable suite of specimens (including

[1] A. W. Stelzner, "Sitzungsber. u. Abhandl. der Isis" (Dresden), 1893 (April), p. 71, calls attention to the fact that these show signs of attrition and that they range in size from a few cubic millimetres upwards, being sometimes large boulders. Among the materials (at Kimberley) he mentions both granite and eclogite.

[2] For the rock itself he proposed the name 'kimberlite.'

[3] In other words, that the volcano (as occasionally has happened) had ejected little or no lava or scoria, discharging only steam and hot water, with shattered rock. This view is held by Max Bauer, in "Edelsteinkunde," p. 225, which, however, I had not seen when this paper was written.

other boulders) from the Newlands Mines, and for the trouble which he has taken in affording me the necessary information.

Prior to the discovery just mentioned, one or two instances had occurred at the De Beers Mine of a diamond apparently enclosed by or projecting into a pyrope. One such, the garnet being the size of a rather large pea, is in the collection at Freiberg (Saxony), to which it was presented in 1892.[1]

The specimen found by Mr. Trubenbach at the Newlands Mine was a piece of blue ground, with a pyrope projecting from one angle. A small, apparently broken, diamond seems embedded at the top. The others (five) are well crystallized, two on one side, three almost in contact on the other. The pyrope (which has a kelyphite rim) seems to be indented by two, but to have once included the others, as they are in contact with the unaltered mineral. We were thus brought so far as to associate the diamond with the pyrope; though this proved no more than the presence of garnets in the parent rock of the diamond, and thus made the eclogite (already known to occur) highly probable, for, as observed by Professor R. Beck,[2] the specimen itself is blue ground. In confirmation of his statement I pulverized a fragment,[3] and find that the powder corresponds with the matrix of the blue ground when similarly treated. The latest discoveries enable me to complete the chain of evidence.

Eclogite Boulders containing Diamonds.

The first-named, that containing several diamonds, is a fragment (perhaps from a quarter to a third) of a boulder, which probably was ellipsoidal in shape, two of the axes being nearly equal and the third distinctly the longest. We may infer that it was rounded from a roughly rectangular block, since the curved surfaces are slightly flatter in the middle parts. The axial lengths in the fragment (prior to removing a piece from one end) were approximately 4 in. by 3 in. by 2 in. The rock is coarsely granular, apparently composed of two green-coloured minerals, one darker than the other (possibly only different states of a single mineral), and of rich resin-pink coloured garnets, varying in size from a hemp seed to a pea, with slightly irregular distribution. The outer surface of the boulder, except for a very small 'step' on one side, is smooth, the garnets barely, if at all, projecting. The latter are covered with a rather soft, dark skin, sometimes slightly thicker than the thumb nail, which often has partly fallen off. This, as can be seen on the broken surfaces, becomes less conspicuous in the inner part of the boulder, and is sometimes invisible to the unaided eye. Two small diamonds are exposed on the curved outer surface, one about half, the other about one-fifth, of an inch from the edge

[1] A. W. Stelzner, "Sitzungsber. der Isis zu Dresden," 1893, s. 85, and R. Beck, "Zeitsch. für praktische Geologie," 1898 (May), p. 163.

[2] Ut suprà.

[3] I could not advise Mr. Trubenbach to have a slice cut from the specimen, as I feared it might be injured, but he kindly detached a little fragment from the opposite end to that named above, which I have thus examined.

of the cross fracture. On the latter surface, nearly an inch below the last-named, three small diamonds appear to lie in a line touching one another, and near them are two others,[1] all four within a space about three-quarters of an inch square; an eighth diamond is about an inch and a half away (on the same face); a ninth, about one-fifth of an inch from the top edge; and a tenth occurs on the larger cross-fractured surface, but near to the edge of the other one. These diamonds are octahedra in form, generally with stepped faces—one, at least, apparently twinned—perfectly colourless, with brilliant lustre; the largest being quite 0·15 inch from apex to apex; the smallest not exceeding 0·05 inch. All seem to be embedded in the green part of the rock. As the outer part of the boulder looks rather more decomposed than the inner, I had a piece removed from one end, thus enabling me to study the mass to a depth of more than an inch from the surface, and examined a strip, about 4 inches long, in a series of five slices.

The late Professor Lewis has given, in the volume already mentioned, so full an account of the minerals which occur in the 'blue ground,' that it will be needless on the present occasion to do more than refer to his descriptions,[2] only calling attention to any variations in the mineral constituents and their association in these eclogites. The constituents are:—

1. (*a*) *Garnet* (Pyrope).—In the slice these appear a light tawny or yellowish red tint, retaining this tint (though much lighter) under the microscope.[3] They are generally clear, with frequent and irregular cracks, but are occasionally traversed by wavy bands of minute enclosures of a pale brown filmy mineral, which is rather irregular in outline, very feebly pleochroic, and gives with crossed nicols fairly bright polarization tints. Similar minerals sometimes have formed along the cracks. They are probably mica, or possibly chlorite, and indicate incipient decomposition. The garnets towards the outside of the boulder, as already said, are enveloped in a 'skin,' and the microscope shows that it usually exists inside, though there it is thinner. In the former case it is generally browner in colour and more distinctly crystalline, corresponding in cleavage, pleochroism, etc., with a mica of the biotite group; in the latter it is greener and more filmy with an aggregate habit and seems to project into the garnet. I regard it as due to decomposition, a form of the well-known kelyphite rim, sometimes a mica, sometimes a chlorite, possibly now and then associated with a little minute hornblende. In a few cases a 'rim' is brown in the outer part and green within. The constituents tend to a parallel rather than a radial grouping. The garnets occasionally contain minute branching root-like enclosures grouped in bands. Though these

[1] It is possible that these two form a twin crystal, but I think they are separate. As the point is unimportant, I have not attempted to clear away the matrix.

[2] We must also not forget the paper by Professor Maskelyne and Dr. Flight (Quart. Journ. Geol. Soc., vol. xxx, p. 406), in which several of these minerals are described, analyzed, and identified. In fact, the authors ascertained everything that was possible with the materials then obtainable.

[3] Unless it is expressly stated, the use of a 1 in. objective may be assumed.

act on polarised light, I regard them as empty cavities, and attribute this to diffraction.

(*b*) *Chrome-diopside.*—The mineral described under that name by Professor Lewis, and referred to by others as omphacite or sahlite. The individuals are sometimes about a quarter of an inch long. In thin slices it is a pale dullish green colour, inclining to olive; under the microscope, a pale sea-green, with a trace of pleochroism. It has one strongly marked cleavage, not however nearly so close as in ordinary diallage, and a second weaker, sometimes approximately at right angles to it.[1] On examining flakes, obtained by crushing, I find the strong cleavage to be clinopinacoïdal and the other probably basal, and obtain on a clinopinacoïd an extinction of 35° with a prism edge. It is in fact identical with the pyroxene described by Professor Lewis[2] as chrome-diopside. In it (though rarely) small rounded enclosures of a greenish mineral aggregate much blackened with opacite. I regard them as alteration products of a ferriferous olivine. This diopside, at the exterior and along cracks, is often converted into a minutely granular to fibrous mineral, which gives a 'dusty' aspect to that part of the crystal, when viewed with transmitted light, and a whitish-green one with reflected light. This often terminates in a minutely acicular fringe, piercing the original diopside. Its grains occasionally are a little larger, showing a cleavage, dull green in colour, fairly pleochroic, and having the extinction of hornblende. A process of secondary change, as in uralite, is no doubt indicated. Now and then a tiny film of brown mica occurs in this part or even in a crack in the diopside.

It is this alteration product which gives the mottled aspect mentioned above as visible to the unaided eye, so this is not indicative of a third important constituent in the original rock. In one of the slices the mica just named attains a larger size (about 0·03 in. across), has a fairly idiomorphic (hexagonal prism) outline, and is not restricted to the margin of the garnet. In this case it is generally associated with calcite,[3] which it tends to surround, and that in one place encloses a radiating acicular mineral (? a zeolite), in another the calcite, or some other carbonate, is mixed with a serpentinous material. Distinct granules of iron oxide are practically absent from the slices, though here and there it may be indicated by some opacite. I have not found spinel, or rutile, or zircon, or pseudobrookite. In fact, putting aside the diamonds, the rock in its unaltered condition was a coarsely holocrystalline mixture of chrome-diopside and garnet, with a few small enclosures of olivine; in other words, it was a variety of eclogite and of igneous origin.[4]

[1] One may give a general idea of their relative importance by comparing them to the columns and cross-joints in some basalts.

[2] Loc. cit., p. 21.

[3] From the facts I think it probably of secondary origin. It reminds me sometimes of the brown mica produced by contact metamorphism.

[4] I am, of course, aware that eclogite, in the past, has been regarded by some geologists as a metamorphic rock. Apart from the fact that several rocks once assigned to this class are now, with good reason, regarded as igneous, I have had

2. A fragment (probably about one-quarter) of a flattish ovoid boulder.—The two broken surfaces, which are nearly at right angles, measure 5 and 5½ in. roughly, and it is about 3¼ in. high. The rock very closely resembles the one just described, except that mica occurs rather oftener and in larger flakes; perhaps the garnets (here also not quite regularly distributed) are slightly more numerous. The outer surface is not quite so well preserved, though enough remains to show that it also has been smooth, and a few thin veins of a white mineral (calcite?) traverse the rock. On this surface, near the meeting of the two fractures, and exposed by the removal of a little material (i.e. it might originally have been just hidden), is a diamond (octahedron), apparently about 0·1in. in diameter. On one side it rests against a pyrope, the adjacent surface of which is incurved, the two minerals being parted by the dull green-coloured kelyphite rim of the latter, which is about 0·03 in. in thickness. Thin sections of this boulder correspond almost exactly with those from the other, the garnets showing precisely the same tints, though traces of a cleavage (roughly parallel throughout) are perceptible on close inspection, and are distinct under the microscope. In garnet such a structure commonly indicates pressure, and the general parallelism accords with this explanation, but the other constituents show no signs of crushing. The 'kelyphite' rims to the garnets are perhaps slightly broader and the brown mica passes into a green (chloritic?) mineral, and occupies cracks in the garnet a little more frequently, but as before the constituents tend to lie parallel rather than radially. One or two of the diopsides show fine oscillatory twinning. The cracks are occupied with calcite or some altered carbonate. There is no real difference between this eclogite and the last-named one.

Eclogite Boulders without Diamonds.

3. Part of a boulder, which must have been about a foot in diameter.—In macroscopic aspect it presents a general resemblance to the rocks described above, with, however, the possibility of a second green constituent. This is not confirmed on microscopic examination. The rock consists, practically, of pyrope and diopside, as already described, except that negative crystals are rather unusually conspicuous in the latter. Into the details of these, as the point seems not to have any bearing on the present investigation, I do not purpose to enter.

4. A fragment, more irregular in form than the others, measures very roughly about 7 in. by 4¾ in. by 3½ in. It retains a good piece of the outer surface, which, though now a little corroded, was once smooth. The rock, which is rather decomposed and crumbly, consists chiefly of three minerals: garnet, not quite so large, paler and more pink in colour than the last-named; an emerald-green pyroxene, and a yellowish or greenish grey, platy to fibrous mineral, suggestive

several opportunities of studying eclogite, and have no doubt as to its origin. Take away the alkali from a magma with the chemical composition of a diorite, and the result would be garnets in place of felspar, i.e., an eclogite.

of a second more altered pyroxene. In thin slices the paler and pinker tint of the garnet is very perceptible, as well as the tendency to a rude and generally parallel cleavage. But we find in it, under the microscope, a few microlithic enclosures, of an apparently colourless mineral, which occurs in long prisms crossed at about 70° by an occasional transverse cleavage, and extinguishing at an angle of about 26° with the longer edge. Many of the cracks exhibit slight decomposition, starting from them, and are sometimes occupied by calcite. The pyroxene, under the microscope, hardly differs from the one already described, except that the green tint is slightly richer and one or two crystals contain the small dark brown negative crystals, common in hypersthene and diallage. The dominant cleavage, as before, is along the clinopinacoïd.[1] The third mineral proves to be an altered enstatite, but I leave the details for the present as it is better preserved in another rock. A fourth constituent is also present, but more sparingly, viz., a pale-brown mica, only moderately pleochroic (phlogophite?). It occurs generally in plates, averaging about 0·1 in. long. The minerals appear to have formed in the following order: (*a*) garnet, (*b*) diopside, (*c*) mica, (*d*) enstatite. As before, iron oxides are very inconspicuous; there may be a grain or two (small) of serpentinised olivine. The marked presence of enstatite distinguishes this rock from the others, but it differs from the eulysites by the substitution of that mineral for olivine, and so links those rocks to the more ordinary eclogites. The occurrence of a little mica indicates the presence of a small amount of an alkali in the magma. If necessary we may name it newlandite, but personally I should prefer to call it an enstatite-eclogite, for I think the coinage of fresh titles more often a bane than a boon to science.

5. This boulder is almost perfect, except that the general flatness of one side indicates either traces of an old fracture or considerable loss by crumbling. The surface has been smooth, but it has suffered from unequal weathering of the minerals. Its girth, in three directions at right angles, is approximately 20½ in. by 19½ in. by 17½ in. It appears only to differ from the last-described in having its garnets a shade more purple, and in an approach to a banded structure; the diopside being rather more abundant in a middle zone, the garnet in one, the enstatite in the other of the outer zones. Being satisfied that it is merely a variety of the last-described rock, I have preferred to leave it as an intact boulder.

6. The next fragment, measuring about 3 in. by 2¼ in. by 2 in., and retaining part of its smooth outer surface, is labelled "found in the yellow ground of No. 2 mine[2] 50 feet deep." Though it is much more decomposed than the others, the purplish garnet, the emerald-green pyroxene, the altered enstatite (here very rotten), and a flake or two of phlogophite (?) are easily made out. It is

[1] As noticed by Professor Lewis, ut suprà, p. 22, in the diopside the prism cleavage has practically disappeared, and a clinopinacoïdal cleavage replaces the orthopinacoïdal usual in diallage.

[2] The others come from another mine (No 1).

obviously a more decomposed specimen of the rock represented by the two preceding specimens.

7. The last of this group of specimens is a rock fragment,[1] measuring about 3½ in. by 2 in. in length and breadth, and slightly exceeding an inch in greatest thickness. Its outline is irregular, being determined by the fracture of the predominant diallage-like mineral. The crystals of this run large, an inch or more in length, breadth, and thickness. It is greyish-green in colour, having one dominant cleavage, with a sub-metallic lustre, and close subordinate cleavages, giving a somewhat fibrous aspect to that surface. Between these large crystalline lumps, numerous small, ill-defined garnets (pyrope) seem crowded, so as to form fairly continuous partings, generally hardly 0·1 inch in thickness. As the readiness with which the rather soft pyroxenic constituent split away made it improbable that a good slice could be cut, and I was reluctant to injure the specimen, I contented myself with detaching a few flakes of this constituent for microscopic work, since the determination of its identity was sufficient for my purpose. These show the mineral to have one easy cleavage and a rather fibrous structure; they give straight extinction parallel with this. As the usual rings and brushes can be seen on the face of easy cleavage, the mineral belongs to the bastite group. The same is true of the enstatite in boulder (4), though, as it is slightly more fibrous, and not in quite so good a condition, the optical picture is less distinct. Thus we may name the rock from which the present specimen has been broken, a garnet-bearing bastitite.

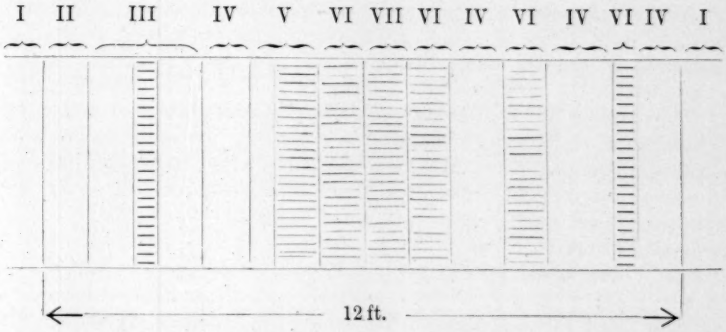
8. This specimen, said to be a fragment of a boulder, is very different from the rest. It is a compact greenish-grey rock containing enclosures, which give it the aspect, at first sight, of a pebbly mudstone. Microscopic examination shows it to be a compact felspathic diabase, with vesicles, which have been filled up with calcite, chlorites, and other secondary minerals (probably zeolites), but not to have any special interest. Its relations appear to be with the rocks occurring in a conglomerate which we shall mention in a later paragraph.

The 'Blue Ground' and Associated Rocks.

Two areas of diamantiferous rock are now being worked at the Newlands Mines. The shape of the one which supplied most of the specimens described in this paper is irregular, and, so far as I know, exceptional. Its outline at the surface may be roughly compared to a rounded triangle into the base of which the point of a rather short shuttle is thrust, the greatest breadth of the two being about equal. Exploratory workings at a depth of 300 feet show that the former area rather quickly narrows, and the latter terminates in clefts; the 'blue ground,' in fact, appears to fill a fissure, broadening in two places to vents which have been traced for some distance underground

[1] I am informed that this was not part of a boulder, but came out of the 'blue ground' nearly in its present condition.

southwards from the principal mass of diamantiferous rock, as represented in the annexed section.



An igneous rock occurs on either side. It is compact, a greenish-grey in colour, not unlike some of the less acid Welsh felstones. Under the microscope it is found to be much affected by secondary mineral changes; the iron oxides alone being in good preservation. A few small crystals of decomposed felspar are scattered in a yet more decomposed matrix, of which the minor details are uninteresting. The rock may be classed with the compact, rather felspathic, diabases. These, farther to the south, turn off rather sharply to east and west.

In the interval, about 12 feet in width, between walls of this diabase, ribs of the 'blue' and a mudstone alternate, the thickest one of the former being from 3 to 4 feet in width, and the inner part of it is in better preservation than the outer. Specimens have been examined from the heart of the mass (vii), a part outside it (vi), and the exterior portion (v). The first (vii) in texture, hardness, and colour reminds me a little of the dark serpentine found north of Cadgwith, in Cornwall. In this matrix roundish spots occur, some darker than it, others a yellow-green colour, besides a few angular whitish spots. The block is traversed by two or three thin calcareous veins. Specimen (vi), while generally similar, is more decomposed, and apparently contains some fragments of shale. Specimen (v) has a stratified aspect, being a dull grey, faintly mottled rock, with streaky, dark, rather carbonaceous-looking bands; the origin being doubtful, till it is seen under the microscope. A fourth specimen (iii) shows the mudstone traversed by a vein of rather pale-coloured decomposed 'blue,' not exceeding an inch in thickness. A fifth (ii) is from near the diabase on the western side, a dark compact rock, faintly mottled, here and there presenting a slight resemblance to a 'blue' traversed by thin veins of a carbonate; and sixth (iv) from a like position on the opposite side is a generally similar rock, but with wider veins filled with more coarsely crystalline calcite. The last specimen represents the 'blue' in the 'neck,' a few yards to the north and at the same level (300 feet). This, inferior in preservation to the first-named,

includes numerous rounded fragments a little darker than the matrix, with others, angular to sub-angular, some also darker and some lighter than it.

A brief summary of the results of microscopic examination may suffice, as these rocks do not materially differ from specimens obtained in the De Beers Mine, of which I have published a full account [1]

The matrix is a mixture, in slightly variable quantities, of granules of calcite or dolomite, serpentine, pyroxene, and iron oxides, in which occur flakes with fairly idiomorphic outlines of a warm-brown mica, moderately pleochroic, corresponding with that described [2] in one or two specimens from De Beers Mine. The prisms are about 0·002 in. in diameter, and sometimes nearly as thick. This mica, which, as stated in a former paper, I consider a secondary product, occurs abundantly in all the specimens, but in that from the interior (on the whole the best preserved rock) it is locally assuming a green colour, no doubt by hydration. In the specimens from the thick rib, the one last named contains mineral grains and rock fragments, except for a few flakes of the usual mica. The former are a mixture of two fibrous minerals, the larger part corresponding with actinolite; the rest, giving lower polarisation tints, may be serpentine. This fact, and structures suggestive of the former presence of a cleavage more regular than that of olivine, make it more probable that diopside was the original mineral. Though iron oxide is present in specks and rods (especially in the worse preserved specimen), this occurs either in the outer part, or as though it had been deposited along cleavage planes. In the thin rib of 'blue' (iii), some of the grains are composed partly of a fibrous mineral, as above described, and partly of a clear one, which often affords rather rich polarisation tints, and presents some resemblance to quartz. Its precise nature is difficult to determine, owing to the absence of distinctive characters, but I believe it to be of secondary origin. Rock fragments are not common in the first (interior) specimen (vii); one, however, is probably an altered shale, and another possibly a limestone. This is bordered by a pale, pyroxenic mineral piercing into the grains of calcite. In the second specimen (vi) fragments are rather common; among them are those of diabase, ranging from fine to coarse, one specimen of the latter, originally, perhaps, an inch in diameter, showing an ophitic structure; felspar and augite both being rather altered, seemingly by infiltration, and one small fragment resembles a sub-crystalline limestone. Specimen (v) does not materially differ, but seems to contain more carbonate than the others. The dark streaking is due to grains of iron oxide or serpentine with much opacite; rock fragments few and small. Specimen (iii) from the thin vein contains a few very small rock fragments, mudstone or shale, more or less altered, possibly also a compact diabase. The 'country rock' is a mudstone, consisting of small chips of quartz

[1] Geol. Mag., 1895, p. 492; and 1897, p. 448.

[2] Geol. Mag., 1897, pp. 450, 451.

and felspar, variable in size, embedded in a dusty matrix, including a carbonate, which is more abundant within about a fiftieth of an inch from the junction. This part is slightly stained, but I was unable to detect any signs of contact metamorphism. Specimens (ii) and (iv) are generally similar, but the former contains some small rounded bits of varieties of diabase, and one may represent a crystalline limestone. The veins are filled with calcite and other secondary products, and are bordered by a very thin film of a brown micaceous mineral, like that described as often permeating the 'blue.' Both specimens suggest micromineralogical changes, such as might be produced by the passage of hot water.

Other specimens of the sedimentary rock in the immediate neighbourhood of the blue have been forwarded to me by Mr. Trubenbach; one, from the adit on the southern side of the section mentioned above, is a grey mudstone, containing a flattish rectangular pebble, of a dark-green compact rock. Two others are from No. 2 mine, or about 700 yards to the south-west. One, struck in the shaft at a depth of 200 feet, is a conglomerate, composed of well-rounded rock fragments, with some scattered grains of quartz. Each of the former is bordered by a zone of a crystalline carbonate (impure calcite), and the interstices are filled, sometimes by a clearer variety of the same, but more often by some minutely granular secondary product. Of the rock fragments, one is a subcrystalline dolomitic limestone; two, perhaps, are chalcedony; the remainder are igneous; the majority being varieties of diabase, sometimes rather decomposed; the rest trachytes, mainly andesites. Their general aspect and the not unfrequent presence of vesicles (now filled with viridite) suggest that they have been furnished by lava-flows. Another specimen, obtained in the same working at a depth of 400 feet, is a rather felspathic diabase, not unlike one of the varieties in the conglomerate. It is a good deal decomposed, is not improbably from a lava-flow, but does not call for a minute description.

Conclusion.

Thus the diamond has been traced up to an igneous rock. The 'blue ground' is not the birthplace either of it or of the garnets, pyroxenes, olivine, and other minerals, more or less fragmental, which it incorporates. The diamond is a constituent of the eclogite, just as much as a zircon may be a constituent of a granite or a syenite. Its regular form suggests not only that it was the first mineral to crystallise in the magma, but also a further possibility. Though the occurrence of diamonds in rocks with a high percentage of silica (itacolumite, granite, etc.) has been asserted, the statement needs corroboration. This form of crystallised carbon hitherto has been found only in meteoric iron (Canyon Diablo), and has been produced artificially by Moissan and others with the same metal as matrix. But in eclogite the silica percentage is at least as high as in dolerite; hence it is difficult to understand how so small an amount of carbon escaped oxidation. I had always expected that a peridotite (as supposed by Professor Lewis), if not a material yet

more basic, would prove to be the birthplace of the diamond. Can it possibly be a derivative mineral, even in the eclogite? Had it already crystallised out of a more basic magma,[1] which, however, was still molten, when one more acid was injected, and the mixture became such as to form eclogite? But I content myself with indicating a difficulty, and suggesting a possibility; the fact itself is indisputable: that the diamond occurs, though rather sporadically, as a constituent of an eclogite, which rock, according to the ordinary rules of inference, must be regarded as its birthplace.

This discovery closes another controversy, viz., that concerning the nature of the 'Hard blue' of the miners (Kimberlite of Professor Lewis), in which the diamond is usually found. The boulders described in this paper are truly water-worn. The idea that they have been rounded by a sort of 'cup and ball' game played by a volcano may be dismissed as practically impossible. Any such process would take a long time, but the absence of true scoria implies that the explosive phase was a brief one. They resemble stones which have travelled for several miles down a mountain torrent, and must have been derived from a coarse conglomerate, manufactured by either a strong stream or the waves of a sea from fragments obtained from more ancient crystalline rocks.[2] The 'washings,'[3] a parcel of which I received from Mr. Trubenbach, also show that the boulders are really water-worn. Besides two unworn pieces of pyrite and a rough bit of eclogite, about three-quarters of an inch in diameter, the pyroxenic constituent of which was a bright emerald green (? smaragdite), I find part of a subangular fragment of chrome-diopside associated with two or three flakes of the usual mica, a well-rounded garnet fully 0·6 inch across, and half a well-worn pebble of eclogite, about one inch long and half an inch thick. The rounded water-worn look of the great majority of the smaller constituents (chiefly garnets and pyroxenes), about the size of hemp-seed, is very obvious. I had suspected some of the grains washings from the De Beers Mine to have been similarly treated; but here it is indubitable, indeed many of the dark green specimens are so smooth outside that they could only be identified after fracture. The ordinary diopside can, however, be recognised, with some of a clearer and brighter green. Most of the garnets are pyropes, but a few resemble essonite. I find also some grains of iron oxide and of vein quartz. Thus, the presence of water-worn fragments, large and small, in considerable abundance, shows the 'blue ground' to be a true breccia, produced by the destruction of

[1] This, however, cannot have been very rich in iron, because diopside does not contain much of that constituent.

[2] As these eclogites are very coarsely crystalline, we are justified in assuming they were once deep-seated rocks, and so much more ancient than the date of the conglomerate. To prevent any misunderstanding I may repeat that the matrix from which these boulders were taken (at various depths, from nearly 100 to about 300 feet) cannot be any alluvial deposit, but is the typical 'blue ground,' practically identical with that in the Kimberley mines.

[3] The name is given to the mineral residue left after washing away the decomposed matrix of the 'blue ground.'

various rocks (some of them crystalline, others sedimentary, but occasionally including water-worn boulders of the former) — i.e., a result of shattering explosions, followed by solfataric action. Hence the name Kimberlite must disappear from the list of the peridotites, and even from petrological literature, unless it be retained for this remarkable type of breccia.

Boulders, such as we have described, might be expected to occur at the base of the sedimentary series, in proximity to a crystalline floor. The Karoo beds in South Africa, as is well known, are underlain in many places by a coarse conglomerate of considerable thickness and great extent, called the Dwyka conglomerate, which is supposed to be Permian or Permo-Carboniferous in age. It crops out from beneath the Karoo beds at no great distance from the diamond-bearing district, and very probably extends beneath it. If this deposit has supplied the boulders, the date of the genesis of the diamond is carried back, at the very least, to Palæozoic ages, and possibly to a still earlier era in the earth's history.

REVIEWS.

I.—Theory of the Earth, with Proofs and Illustrations. In Four Parts. By James Hutton, M.D., F.R.S.E. Vol. III, Edited by Sir Archibald Geikie, D.C.L., F.R.S. 8vo; pp. xvi, 278, with Index to Vols. I and II. London, 1899. Published by the Geological Society, Burlington House, London. Price 3*s.* 6*d.*

IN the annals of Geology, Hutton's "Theory of the Earth" ranks as one of the principal classics, and if this original work has been to some extent eclipsed by Playfair's lucid "Illustrations" of it, the fame of the author and his influence on the progress of geology have thereby been greatly enhanced. Of the four parts which the "Theory of the Earth" was planned to comprise, two only were published (in separate volumes) in Edinburgh in 1795, two years before the death of the author. An incomplete MS. of the third volume, intended to embrace the third and fourth parts of the work, has long been in the possession of the Geological Society. This MS. commences with Chapter IV; the efforts to discover the earlier portion having proved unsuccessful. It is remarked by the Editor that although there is reason to believe that the MS. of Vol. III was nearly ready for the printer at the time when the other two volumes were published, yet it is possible that the want of drawings to illustrate the text may have caused the delay. The six chapters now published deal mainly with Hutton's views regarding the origin of granite; they include narratives of his excursions into different parts of Scotland, notably to Glen Tilt, to Galloway, and to the Isle of Arran. As the Editor points out, Hutton's Essay on Arran "is a masterpiece of acute observation and luminous generalization. Had it been published in his lifetime, it would have placed him at once as high in the ranks of field-geologists as

he admittedly stood among those of the speculative writers of his time."

We may quote a few passages in reference to the visit to Arran which was made in 1786 :—

"In setting out upon that expedition, I had but one object in view; this was the nature of the granite, and the connection of it with the contiguous strata. . . . Our head-quarters were at Brodowick [Brodick], and our first object was to examine around the mountain of Goatfield for the connection of the granite with the strata or surrounding bodies. This, however, cost us a great deal of trouble to accomplish. . . . After making some other fruitless attempts, I set out on horseback for Loch Ranza; with a view to investigate the same object by the way, as well as to examine the north end of the island, where I knew the coal and slate were worked near the shore. Upon this road I observed that the North Sanox river, which I had crossed in entering the schistus district to the north, runs nearly in the junction of the schistus and the granite mountains, the characters of which are very distinguishable to the view. I then went forward, but in returning I quitted my horse, and went over the mosses and muir towards the heads of that North Sanox river which there divides into two streams. Here I had the satisfaction to find the immediate junction of the schistus with the granite, in the solid rock, exposed perfectly to view, and that in both of these rivulets, a little way above their junction. Nothing can be more evident than that here the schistus had been broken and invaded by the granite; as in this place the regular stratification of the vertical schistus is broken obliquely by the other rock, and parts of the schistus involved or almost insulated in the mass of granite, which from this junction enters and traverses the body of the schistus in little veins terminating in capillaries."

This and many other passages show the care and discrimination with which Hutton pursued his observations, and the remarkable insight he showed in determining the geological structure. In his visit to Arran, as in his "Journey to the North Alpine part of Scotland," in 1785, the question before him was how far the granite "is to be considered as a primary mass in relation to the alpine schistus; in that case, fragments of the granite might be found included in the schistus, but none of the schistus in the granite."

In elucidation of the text the Editor has inserted numerous explanatory notes, which are full of interest in themselves, and will greatly aid the reader. Moreover, he has most effectively supplied the place of the missing drawings by original pictorial views and drawings taken by himself in Arran while specially following Hutton's route with his description in hand. Other illustrations borrowed from publications by Macculloch and the Geological Survey are introduced to make clear particular features described in the work. The Editor has furnished an index to the volume, and also a separate index to vols. i and ii—a contribution which will be much appreciated by the happy possessors of those volumes.

We may heartily congratulate Sir Archibald Geikie and the

Geological Society on the publication of this work, which is not only a tribute to the memory of one of the Early Fathers of Geology, but one which will be read and appreciated by all interested in the history of the science.

II.—Cape of Good Hope: Annual Report of the Geological Commission for 1897.

THE main features of the report for 1897 are the accompanying map and sections. The map is on a reduced scale of 12·62 English statute miles to one inch, and shows the geology of the area stretching from the west coast eastward to the Gamka River, and from the Zwarteberg Mountains on the north to some distance south of the Langebergen. The map is clearly printed in colours, the major faults being successfully represented by a narrow uncoloured band. The structure of the area is illustrated by five horizontal sections drawn across the intervening districts situated between Worcester on the west and Ladismith on the east.

The report itself is marked by commendable caution, there being an entire absence of the highly coloured descriptions so usual in African geological literature.

The Commission is to be congratulated on the amount of work done, and the interest and importance of the results obtained. Especially worthy of praise is the adherence to a plain statement of facts in place of building up, on insufficient data, elaborate and fascinating theories.

The succession established by Bain and Dunn is in the main adhered to, the formations in descending order being given as follows:—

Conglomerate, Gravels, Sands, and Limestone.
Ecca Beds.
Dwyka Series.
Witteberg Beds.
Bokkeveld Beds.
Table Mountain Sandstone.
(Marked unconformity.)
Malmesbury Beds.
Granite intrusive in Malmesbury Beds.

The Malmesbury Beds cover wide areas round Hopefield and Malmesbury, and are represented as forming a narrow strip north of the great dislocation known as the Worcester-Robertson Fault, between Tulbagh on the north-west and Swellendam on the south-east, and also a small triangular patch east of Ladismith and south of the Zwarteberg. One of the greatest alterations from the excellent map of Mr. Dunn is the withdrawal of the Malmesbury Beds from the Caledon district, and the insertion of strata of Bokkeveld age in their place, thus returning to the mapping of A. G. Bain. The Malmesbury are considered to be the oldest rocks seen at the Cape, the Namaqualand schists and gneiss of Mr. Dunn

and other writers on South African stratigraphy not being recognized as separate divisions.

The Malmesbury Beds consist of micaceous slates, fine compact quartzites, phyllites, and mica schists, as predominant rocks, with bands of crystalline limestone and beds of sheared conglomerate. Ottrelite schists are not uncommon in the series from the Hex River to Swellendam. The intrusive rocks are granite, quartz-porphyry, and diabase, considerable areas being shown on the map between St. Helena Bay and Malmesbury and around Paarl and Stellenbosch. The granite is a coarsely porphyritic biotite granite; segregation veins are numerous and form considerable masses. The granite often shows distinct evidence of shearing.

Between the Malmesbury Beds and the overlying rocks a great unconformity is everywhere noticed. The Table Mountain Sandstone Series on Table Mountain, though lying flat, is described as having been subjected to considerable earth movement, as shown by the presence of vertical cleavage and occasional shearing. In the mountains beyond Mitchells Pass and Hex River, and in the Kloofs and Passes of the Zwarteberg and Langeberg, magnificent examples of the twisting and curving to which the Table Mountain Sandstone has been subjected are seen. The Table Mountain Sandstone consists of coarse sandstones and quartzites, with subordinate bands of shale; no fossils have been found.

The Bokkeveld Beds, which conformably succeed the Table Mountain Sandstone, consist of sandstones and shales, but the latter play a much more important part than in the Table Mountain Sandstone Series. Many fossils of Devonian facies are found.

The Bokkeveld Beds pass up into another sandstone and shale group with bands of quartzite, called the Witteberg Beds in the report. These correspond to the Zwarteberg Quartzite Series of other writers; the alteration of name being necessary as the Zwarteberg Mountains are found by Mr. Rogers to consist of Table Mountain Sandstone. The only fossils found in the Witteberg group are plant remains and the curious markings called *Spirophyton*, of doubtful organic origin, but said to be very characteristic of this group.

The Table Mountain Sandstone, Bokkeveld and Witteberg Series, are sometimes grouped together as the Cape Formation. The thickness cannot be estimated, but the three groups form a conformable series of quartzites, sandstones, and shales, several thousand feet thick.

The Dwyka Series and Ecca Beds are described as conformable to the Witteberg Group. This is an important result, as the Dwyka has been generally described as unconformable to the Witteberg Group. Considerable interest is also attached to the discovery by the Commission of strata of Dwyka and Ecca age around Worcester, to the south of the Worcester-Robertson fault, showing the further extension southwards of these beds than was hitherto expected. The presence of *Gangamopteris* in the beds at Worcester places this discovery beyond dispute.

Some interesting facts, throwing light on the origin of the Dwyka, have been obtained by the Commission. The most important is the discovery of undoubted scratched stones, resembling true glaciated pebbles; a large boulder of granite, 10 feet by 8 feet in section, was found lying in the Dwyka in the poort, where the Witteberg River cuts across the Dwyka ridge, south of Lainsberg. The pebbles consist of several varieties of granite, several kinds of more basic igneous rocks, sandstones, quartzites, argillaceous and calcareous rocks, and vein quartz. There are distinct bedding planes in the rock, and the bedding is everywhere conformable to that of the quartzites of the underlying Witteberg Group.

Extensive superficial deposits, probably in most cases of recent origin, are mapped in several localities. The most interesting of these are the sand dunes on the shores of False and Table Bays and over large areas in the Malmesbury district. In some places the entire mass of the dunes has been converted into a more or less compact sandstone or limestone, that at Saldanha Bay being quarried as a building stone. These deposits have sometimes been taken as of Tertiary age, but the occurrence in them of recent shells, often of terrestrial genera mingled with bones of rhinoceros, elephant, etc., points to their recent origin. WALCOT GIBSON.

MEMOIRS OF THE GEOLOGICAL SURVEY.

III.—THE WATER SUPPLY OF SUSSEX FROM UNDERGROUND SOURCES. By WILLIAM WHITAKER, F.R.S., and CLEMENT REID, F.L.S., F.G.S. 8vo; pp. iv, 123. (London: printed for H.M. Stationery Office, 1899. Price 3*s*.)

MR. WHITAKER, more than any other member of the Geological Survey, devoted attention during his long official career to the important applications of geology to questions of water supply. Now that he has retired from the Survey he has been good enough (as the Director-General points out) to assist Mr. Reid in arranging the numerous records of well-sections, which form the bulk of the present Memoir. The work, in fact, contains all information which could be obtained concerning the well-sinkings and borings in Sussex, with analyses of many of the waters, and a brief introductory account of the geological formations met with in the county. It cannot fail to be of great practical value.

DESCRIPTIVE MONOGRAPH OF THE AMMONITE GENUS *PERISPHINCTES*.

IV.—MONOGRAPHISCHE BESCHREIBUNG DER AMMONITENGATTUNG PERISPHINCTES. By Dr. JOS. VON SIEMIRADZKI. Palæontographica, Bd. xlv (1899), pp. 69–352, pls. xx–xxvii.

THE Ammonite genus *Perisphinctes*, founded by Waagen in 1869 as a subgenus of *Stephanoceras*, and shortly afterwards raised to generic rank by Neumayr, Zittel, and Waagen himself, has now become so large that any attempt to classify the forms which have been included in it is not only a difficult task, but entails a vast

amount of labour and research. For the present monograph of this very extensive genus the author therefore deserves our best thanks. He tells us that in its preparation he has consulted 128 separate publications in German, French, English, Italian, Spanish, Polish, and Russian; and that besides his own collection, which contains several hundred examples of the genus, he has examined the collections of several private individuals, as well as those of various Continental museums. In some cases in which the author was unable to see the type-specimens he obtained plaster casts of them, in order to gain a correct idea of the species. One great difficulty in dealing with this genus is caused by the very vague manner in which several specific names, such as *biplex*, *plicatilis*, *polyplocus*, and *polygyratus*, have been used, due in some cases to the inadequate description or figure of the type-specimen. The author concludes that a precise limitation of the genus from allied genera is not possible, and that its limits must be drawn somewhat artificially. The author devotes a short but interesting chapter to the morphology of the shell, and then proceeds to the classification of the genus, in which he recognizes about 367 species, only a few of which are new. His investigations lead him to divide the genus into six sections, which he groups into five subgenera, thus:—I, *Grossouvria*, n. subgen. (including II, *Biplices*, Sutner); III, *Ataxioceras*, Fontannes; IV, *Perisphinctes*, s. str.; V, *Procerites*, n. subgen.; and VI, *Choffatia*, n. subgen. These are divided into 'Mutationsreihe,' or developmental series, and these again into 'Formenreihe,' or groups of contemporaneous species. The author gives a description of each species, lateral views of the new forms and of some others are given on the eight photographic plates accompanying the work, an outline of the transverse section of the whorl and a drawing of the suture-line of many of the species being given in the illustrations which are included in the text. There is an index to the work, but this appears to be somewhat incomplete. G. C. C.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 10, 1899.—W. Whitaker, B.A., F.R.S., President in the Chair. The following communications were read:—

1. "The Geology of the Davos District." By A. Vaughan Jennings, Esq., F.L.S., F.G.S.

Alpine geology has attracted many workers since the date of Professor Theobald's classic memoir on the district of which Davos forms part, and new principles of interpretation have been established. The author has more especially studied (*a*) the age of certain rocks formerly classed as 'Bündner Schiefer,' but distinct from the grey shales variously regarded as of Jurassic or Tertiary age; (*b*) the origin and date of the serpentine near the Davoser See; and (*c*) the tectonic structure of the district. The following

rock-groups occur in the neighbourhood treated of:—(1) Gneisses and crystalline schists more ancient than any of the others; (2) the Cassana Schiefer, a name applied to a variable group of rocks, ranging from true schists to dark shaly rocks, apparently less crystalline and more recent than the above-named, but older than (3) the Verrucano, a conglomerate or grit with occasional mudstones, sometimes associated with a quartz-porphyry, the last representing the well-known rock in the Botzen district; (4) the 'Mittelbildung' of Theobald, strata intermediate between the Verrucano and the Haupt-Dolomit, very variable in lithological character, in which sometimes the Arlberg Kalk and Virgloria Kalk can be identified, and typical rauchwacke, which occurs at two levels. Above this comes (5) Haupt-Dolomit of the usual character, followed in places by beds (6) of Rhætic age. Of more local occurrence are (i) serpentine, a large mountainous mass on the western side of the Davoser See, with a narrow extension northward and southward for a considerable distance; (ii) red and green schistose rocks; (iii) radiolarian chert; (iv) breccias; (v) the so-called talc-granite; and (vi) diabase, among which, at Arosa, is a variolite. The schistose rocks (ii) are common in the neighbourhood of the East Alpine serpentines, and in this region the latter rock passes down on the western side into ophicalcites, which are followed by a confused mass of layers of serpentine alternating with reddish calcareous or argillaceous bands. These the author considers to indicate a physical condition rather than a geological horizon. With the red and green schistose rocks, which he refers to the Mittelbildung, radiolarian cherts are associated. These have been examined by Dr. G. J. Hinde, who states that the radiolaria are not sufficiently well preserved for specific identification, but have rather a Jurassic facies, though they also resemble radiolaria, described by Professor Parona from Cesara, which that author regards as at any rate not newer than Lower Trias.

The author discusses at length the physical structure of the district. The general trend of the Davos Valley is rather oblique to that of the greater rock-masses, which, however, is somewhat irregular. He shows that these (which have a general dip towards the south and east) form three great acute and rudely parallel overfolds, the westernmost being the most complicated; of this fold the serpentine forms a part. It is more recent than the crystalline schists and the Casanna Schiefer, and is associated with the red and green schistose rocks already mentioned, in a way which he considers indicative of intrusion; but it nowhere cuts the Haupt-Dolomit. Accordingly he considers it to be later than the Verrucano, and not earlier than the middle part of the Trias. Certain crystalline breccias occur in the neighbourhood of the serpentines; these the author considers to be due to earth-movement, and he goes on to give reasons for regarding them as the equivalent of the Casanna Schiefer of other localities. There is, in his opinion, no evidence of the presence of post-Jurassic strata such as Professor Steinmann believes to exist.

2. "Contributions to the Geological Study of County Waterford. Part I, § 1: The Lower Palæozoic Bedded Rocks of the Coast." By F. R. Cowper Reed, Esq., M.A., F.G.S.

This paper opens with an account of the previous publications on the geology of the district, and then goes on to describe the sections exposed along the coast at the following localities:—Raheen and Newtown Head, Tramore Bay, Garrarus and Kilfarrasy, Annestown and Dunabrattin, Knockmahon, Ballydouane Bay, and Killelton Cove to Ballyvoyle. These sections expose shales and limestones with abundance of igneous rocks partly interbedded, but mainly intrusive; and the author is able to make the following succession of rocks, tabulated in descending order:—

4. Raheen Series. Mudstones, slates, felsites and tuffs, and fossiliferous shales.
3. Carrigaghalia Series. Graptolitic shales, thin flags, cherts, tuffs, and felsites.
2. Tramore Limestone Series. Divided into three stages.
1. Tramore Slates. Calcareous and argillaceous slates.

Nos. 3 and 4 are represented by barren limestones at Dunabrattin, and 1, 2, and 3 by felsites and tuffs at Newtown Head.

The palæontological portion of the paper gives the previously published lists of fossils, including those recorded by McCoy in his "Synopsis." The author has examined and re-identified all McCoy's specimens. A further list gives the peculiar species hitherto found in the British Islands only in Waterford. The chief species are then dealt with in detail: a number of new species of trilobites and brachiopods, and one new genus of trilobites, being described.

Petrological notes of the interbedded igneous rocks are next given. These are lavas and tuffs, all acid in composition and possessing from 75 to 78 per cent. of silica. The groundmass is generally cryptocrystalline, but spherulitic, granophyric, nodular, perlitic, and fluxion structures are common. Phenocrysts do not appear to be common; plagioclase-felspar predominates over quartz, and that over orthoclase, but felspar-microlites are of frequent occurrence.

The author has previously compared the Tramore Limestones with the Balcletchie Shales of Scotland; but he now considers that they mainly represent beds on a lower horizon, as they are overlain by rocks displaying a Glenkiln facies. The fauna of the Limestones themselves presents so peculiar a facies that they have often been considered to be of Bala age. Although the graptolites of the Carrigaghalia Series correspond with those of the *Dicranograptus*-shales of South Wales, the underlying (Tramore) limestone has not the fauna of the Llandeilo Limestone, but corresponds more nearly with the *Orthoceras*-limestone of Sweden. The characteristic genera *Porambonites*, *Amphion*, *Echinosphæra*, and *Glyptocystis* are common to the Tramore Limestone, the *Orthoceras*-limestone, and the corresponding Echinospherite Limestone and 'Vaginatenkalk' of Russia, while there is also a likeness in the abundance of *Pterygometopus* in Russia and Waterford. A list of common and allied or representative species is given in the paper. Stage 1 of the Tramore Limestone may include beds as low as or lower than

the *Megalaspis gigas* zone = B_3 Vaginatenkalk of Russia; Stage 2 may especially be compared with the Echinospherite Limestone; and Stage 3 probably partly represents the upper part of this Limestone and the lower part of the overlying Kuckers Shales C_2. The *Didymograptus*-shales have not yet been identified, though it is just possible that the Tramore Slates may represent them.

The Raheen Shales of Newtown Head contain *Orthis argentea* in abundance, and may be compared with the *O. argentea* zone, which in South Wales comes above the *Dicranograptus*-shales. But these beds also contain species peculiar to them, and others with a Scandinavian or Russian affinity; and the shales may be compared with the upper part of Tullberg's Series E of the Middle Graptolite Shales. The occurrence of this East European Lower Ordovician fauna in the western part of the British Isles is of great interest with reference to questions of ancient bio-geographical provinces; and it seems to require that the coastline along which this littoral fauna flourished stretched round from Scandinavia so as to approach the south-eastern corner of Ireland, while deeper-water conditions coexisted in Wales and England. Volcanic activity began about the period of the accumulation of the *Dicranograptus*-shales near Tramore, and possibly earlier at Raheen, where it also continued till after the *Orthis argentea* beds had been deposited.

II.—May 24, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

The President called attention to the issue of vol. iii of Hutton's "Theory of the Earth," and said that the thanks of the Fellows were due to Sir A. Geikie for having edited and annotated most carefully this work. The volume was printed from a previously unpublished manuscript which had been for many years in the possession of the Society: its contents were extremely interesting, and it supplemented the previous volumes by the inclusion of an index to the whole of the work, prepared by Sir A. Geikie.

Professor Seeley exhibited a cast from a footprint obtained by Mr. H. C. Beasley from the Trias at Stourton. The impression is about 1½ inch long, and nearly as wide. The cast has been treated by oblique illumination, so as to display its osteological structure by means of the shadows thus thrown. All the claws are directed outward, as in a burrowing animal. The form of the foot resembles that of a monotreme mammal rather than that of any existing reptile. There appears to be a slender pre-pollex including three bones. The only other example of this structure in the Trias is in the Theriodont reptile *Theriodesmus*, in which it is less definite. This character may add to the interest of other footprints from Stourton, which in the form of the foot approximate to Anomodont reptiles from the Karoo Beds of Cape Colony.

The following communications were read:—

1. "On the Distal End of a Mammalian Humerus from Tonbridge." By Prof. H. G. Seeley, F.R.S., F.G.S.

The bone described in this communication was found in 1898 by Mr. Anderson on the bank of the River Medway, near Tonbridge. It was seen projecting from reconstructed rock which contained fragments of flints among other materials. Traces of matrix at the distal end show that the specimen has been derived from quartz-sand bound together with limonite, such as might occur in the Hastings Sand, Wealden Clay, or Lower Greensand. Conditions of mineral structure and osteological character incline the author to believe that the bone was originally contained in the Wealden Clay. The fossil is 4 inches long, and indicates a humerus which may have been 6 inches in length when perfect, as large as that of a wolf but smaller than that of a bloodhound. The form of the shaft precludes any comparison with the carnivora, and indicates a resemblance to ungulate types. When the bone is held vertically and seen from the front, the condyles are oblique—a character not observed in any other animal. The weight of evidence appears to incline towards reference of the fossil to the Artiodactyla, but it probably indicates a new family type.

2. "On Evidence of a Bird from the Wealden Beds of Ansty Lane, near Cuckfield." By Prof. H. G. Seeley, F.R.S., F.G.S.

A fragment of bone found, by Mr. Neville Jones, a member of the London Geological Field Class, embedded in sandstone was identified by the author as probably the distal end of the femur of a bird. The external condyle is not only larger and deeper than the inner, but is more prolonged distally—perhaps the most distinctive avian character of the bone. *Colymbus* is the only existing bird to which the fossil makes any approximation, but the resemblance is distant and not suggestive of near affinity, and it is interesting that the Cretaceous birds show so marked an affinity with that type. The resemblances of the Dinosaurian and Crocodilian femora with this type are such that almost every individual feature of the bone can be paralleled in some fossil referable to these groups, but there are no British dinosaurs of so small a size or possessing some of the marked features shown by this bone.

3. "Notes on the Rhyolites of the Hauraki Goldfields (New Zealand)." By James Park, Esq., F.G.S., and Frank Rutley, Esq., F.G.S.; with Analyses by Philip Holland, Esq., F.I.C., F.C.S.

Part i of this paper, by Mr. J. Park, gives a description of the rhyolites as seen in the field. After a rest from volcanic action during the Secondary Period, the Tertiary eruptions burst forth and were more widespread than those of recent times. In the Hauraki Peninsula the basement Palæozoic rocks are covered by richly fossiliferous marly clays and limestone of Lower Eocene age, and these by a vast accumulation of andesitic lavas and tuffs, in places 3,000 feet thick. These andesites are the gold-bearing rocks of the district, and they are succeeded by rhyolitic lavas and ashes. Both andesites and rhyolites were influenced by solfataric action, resulting in siliceous deposits rich in gold and silver. The rhyolites rest on rocks probably of Upper Miocene age, and are

followed by Pleistocene and recent deposits; so that they probably range from older to newer Pliocene in date.

Part ii contains the observations of Mr. Rutley on the petrology of the rhyolites. The rocks present occasional occurrences of perlicity, and the lithoidal types sometimes owe their characters to subsequent devitrification, sometimes to the effect of cooling on or immediately after eruption. Reheating has at times reduced the felspars to the condition of felspar-glass. Although plagioclase-felspar is common, the analyses indicate that the series must be retained with the rhyolites, it being quite possible that some of these minerals may have been derived from the andesites. In the rocks of Omahu, branching spherulites of microfelsitic material are described in detail, the microfelsitic substance being an imperfectly devitrified glass of fibrous aspect, the fibres having an imperfectly margaritic or longulitic character. Among the fibres often lie filmy scales which may possibly be tridymite. The term microfelsite is considered worthy of retention, as it denotes a phase of devitrification not adequately expressed by any other name: "while its abandonment would produce a gap which could only be bridged by much circumlocution."

4. "On the Progressive Metamorphism of some Dalradian Sediments in the region of Loch Awe." By J. B. Hill, Esq., R.N. (Communicated by Sir A. Geikie, D.Sc., LL.D., F.R.S., F.G.S.)

The region under discussion contains two principal series of rocks, passing one into another without a break, and conveniently referred to the Dalradian System:—(1) The Ardrishaig Series (phyllites and fine-grained quartzites). (2) The Loch Awe Series (black slates, limestones, grits, and quartzites). The latter series lies in a gentle trough of the former. Even in their most altered state, the clastic nature of the rocks of the Loch Awe Series is apparent. Both Series are pierced by innumerable intrusive sills of epidiorite, hornblende-schist, and chlorite-schist, modified diorites and gabbros, which effect contact-metamorphism in the bordering sediments. Intrusive rocks of post-schistose date also occur, like the Glenfyn granite, the granite of Ben Cruachan, and smaller masses of granite, monzonite, hyperite, ultrabasic rocks, quartz-porphyries, felspar-porphyries, porphyrites, and lamprophyres; these are in their turn cut by dolerite and basalt-dykes. All these rocks exhibit progressive metamorphism when traced towards the north-east and towards the Central Highlands, a character best seen in the loop formed by the rocks near the head of Loch Awe. The Ardrishaig phyllites, almost clay-slates, pass into mica-schists of the normal Central Highland types. The Loch Awe limestones become epidotic, and contain biotite, garnet, and actinolite, the crystals of the last mineral being sometimes 1 inch long. The black slates acquire garnets and actinolite. The grits and quartzites become granulitic, and pass into gneissose rocks with black and white mica, garnets, actinolite, tourmaline, epidote, and red felspar; they pass into the quartzites, gneissose flagstones,

and biotite-gneisses of the Central Highlands, without anywhere reverting to the approximately unaltered condition which they exhibit to the south-west. The sills become granulitized and partly recrystallized, with biotite and garnets.

These rocks, which occur on the strike of the Central Highland schists, are linked with the latter by the persistence of the Loch Awe rock-types, including the boulder-bed, which is regarded as having a definite stratigraphical position. It is true that when traced along the strike the metamorphism increases rapidly towards such granite-masses as that of Ben Cruachan, but the same type of metamorphism continues into the Central Highlands, and into regions so remote from the granite that the author is driven to believe that "without the presence of the Cruachan granite the increasing metamorphism, though possibly more gradual, where that granite now occurs, would have been equally apparent." Evidence of metamorphism when the rocks are traced across their strike is also adduced.

Although the author does not go very fully into the question of the causes of the progressive metamorphism exhibited in tracing these rocks towards and into the Central Highland schists, he had reason to suspect that "the intense regional type of metamorphism was linked with the same phenomena that afterwards resulted in the irruption of the granite-masses."

III.—June 7, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Mr. F. A. Bather, in exhibiting, on behalf of Mr. R. D. Darbishire, a pebble found in gravel near St. Margaret's, Bowdon (Cheshire), said that it consisted of liver-coloured quartzite, and no doubt once formed part of the Bunter Pebble-beds, though these do not occur in the immediate neighbourhood of Bowdon. It had been reported to Mr. Darbishire as found in river-gravel; but reference to Sheet 80 N.E. of the Geological Survey map (1 in. Drift) showed that the deposit was Drift of alleged glacial origin. The specimen was an exceedingly perfect and characteristic example of the pyramid-pebbles or 'Dreikanter,' such as are found in the 'Diluvium' of the North German plain, and in other parts of the world from the Cambrian to rocks now forming, but hitherto not recorded from England. These have been explained as due to: (1) human agency, (2) glacial action (Theile), (3) compression in a pebble-bed ('Packungstheorie' of Berendt), and (4) action of wind and sand. The last explanation was the only one that met the facts of the case, as proved by A. von Mickwitz (Mém. Soc. Imp. Minéral. St. Pétersb., ser. ii, vol. xxii, pp. 82–98, pls. viii, ix, 1887).

In illustration of his remarks, Mr. Bather exhibited a series of specimens which had been collected under the guidance of M. Mickwitz from the locality described by that author on the shore of the Obersee, south of Reval, Esthonia. They confirmed the statement that the three sides of the pyramids lay at right angles

to the directions of the prevailing winds of the district; they showed stages between stones eroded on one face, or on two faces, and the typical 'Dreikanter'; they illustrated the polishing action of the agent on hard, fine-grained material, its differentiating action on coarse-grained; they retained the original water-worn surface and shape on the under side, and a growth of lichen on such small portions of the upper surface as had been sheltered from the wind. Applying this explanation to Mr. Darbishire's specimen, there still remained an unsolved problem: Was the pebble eroded before or during the deposition of the Bunter stratum, or at some time before, during, or subsequent to the transport and deposition of the Drift? The mode of occurrence of the North German specimens shows that they were eroded after the deposition of the beds at the top of which they now lie; and, in the absence of contrary evidence, the same answer must be given provisionally to the preceding questions.

The following communications were read:—

1. "On the Geology of Northern Anglesey." By C. A. Matley, Esq., B.Sc., F.G.S.; with an Appendix on the Microscopic Study of some of the Rocks, by Professor W. W. Watts, M.A., Sec. G.S.

The strata which occupy the northern part of Anglesey have been the subject of much controversy, some geologists considering them (with the exception of a few patches in the extreme north) to be pre-Cambrian, while others maintain that they are of Bala age, and that they are an upward continuation of the black slates that everywhere appear to underlie them to the south.

The author attacks this problem from its palæontological as well as its stratigraphical side. He divides the rocks into three groups, namely: (1) the 'green series,' which forms the floor of the greater part of the area; (2) the 'northern complex,' occupying a tract along the northern coast and including in it (3) some undoubted Ordovician strata. He adduces palæontological evidence that the Ordovician rocks lying in the northern complex are mainly, if not wholly, of Llandeilo age, while the black slates of Central Anglesey appear to range into Llandovery. The field-evidence shows *inter alia* that the asserted interstratifications of the Green Series and the southern Ordovician are the deceptive results of thrust-planes which have driven the barren green rocks over the Ordovician beds, the latter being in other places made up of fragments derived both from the Green Series and from the rocks of the northern complex.

The contortion, overfolding, cleavage, dislocation, and disruption which the rocks have undergone are next described. Disruption is traced from its early stages into 'crush conglomerates.' Some of the disrupted rocks are Ordovician, and traces of ancient dykes have been found rent to pieces by the movement, which is stated to be post-Ordovician and pre-Carboniferous. The detached masses of limestone and the isolated 'quartz-knobs' of the northern complex are considered to be portions of strata which have suffered

disruption in the same way as the thinner hard bands in the crush-zones.

The author contents himself with a general account of the Ordovician rocks near Cemmaes and Porth Wen. He includes among them a purple conglomerate and the *Orthis Bailyana* beds. Though much inclined to the opinion that the green strata and the northern complex are pre-Cambrian, he admits the possibility of their being of any age up to and including the Arenig.

The Appendix contains notes on some of the rocks from the Green Series and the Ordovician System, the quartzites, and the crush-conglomerates.

2. "On an Intrusion of Granite into Diabase at Sorel Point (Northern Jersey)." By John Parkinson, Esq., F.G.S.

In the early pages the general character of this intrusion is described. From a consideration of the field-evidence the author concludes that only the earlier injections of the intruding granite did the work of melting and absorption; that a latter injection, probably with no pause, succeeded, taking the same direction as that followed by the first, and carried forward with it this earlier granite, now rendered basic through the more or less complete absorption of diabase fragments. There has been no diffusion of the basic material thus acquired through this second granite. It is pointed out that this explains the intermingling and interstreaking of the two varieties of granite seen on the coast; the one porphyritic and crowded with fragments, the other non-porphyritic and devoid of fragments.

Following this general introduction, the characters of the granite are described in some detail; then those of the diabase, formerly an ophitic dolerite. Details of structure of the granite in which absorbed basic material is present, and of the diabase into which acid material has permeated, are dealt with: particular attention being directed to the great alteration which the diabase has undergone; this has frequently amounted to a total reconstitution. In this connection are noticed the prevalence of biotite as a product of such mixing and reconstitution when acid material is present in quantity, and the almost entire absence of augite under similar circumstances. In rocks of heterogeneous origin into which the diabase has largely entered, similar features are described: the presence of nests and veins of acid minerals, the entire loss of ophitic structure, the frequent occurrence of much quartz, and the presence of a mineral believed to be sillimanite. The corrosion and reconstitution of the acid felspars under some circumstances are figured and described; the early stages of such alterations are touched upon, and a table is given showing the gradual increase in specific gravity with increase of absorbed material.

In conclusion, points of resemblance and of difference are noted between this district and others; and an interesting slide from Alderney is described, showing the probable extension of such rocks in other directions.

CORRESPONDENCE.

THE RIVER OF THE BALTIC.

Sir,—In reference to Professor Bonney's letter in the Geological Magazine for this month, will you allow me to say that some light on the origin of the remarkable channel which follows the southern coast of Norway seems to be thrown by reference to Dr. Kjerulf's map of the ice-striæ and course of the erratic blocks in his work, "Geologie des Süd. und Mit. Norwegen," Taf. vi, p. 25, from which it will be seen that the erratic blocks have been carried for long distances westwards along the path indicated by the deep channel between the Christiania Fiord and Stavanger. On the other hand the land striæ point southwards; so that the direction of the ice-drift on the submerged portion is perpendicular to the general course of the movement of the ice on the land to the north. The question arises, were the movements of the ice on the land southwards, and that of the ice westwards, on the coast, contemporaneous; or do they represent different epochs of the Pleistocene period? If contemporaneous, the land-ice must have been diverted from its normal course by some opposing barrier; if referable to different epochs, the erratic blocks may have been carried by floating ice along with the trend of the current passing outwards through the Skager Rak; or they may have been carried by land-ice during an epoch of elevation, while the ice itself, in the form of a great glacier, may have ploughed out the loose material with which the whole floor of the Skager Rak may once have been covered, and piled it up on either hand as it moved along. The origin of this channel is certainly a difficult problem; but I feel satisfied it can only be solved by considerations connected with the movements of the land-ice over the unsubmerged portions and those of the submerged. Edward Hull.

June, 1899.

THE GEOLOGY OF THE COUNTRY AROUND CARLISLE.

Sir,—In your review of Mr. Holmes' Memoir of the Geology of the Country around Carlisle, you state that "the conclusions at which Mr. Holmes arrived were not those to which Mr. Aveline and the late Sir Andrew Ramsay could agree." As I have never seen Mr. Holmes' Memoir, or knew that it was published, I do not know what these conclusions are. But I have always maintained that no part of the St. Bees Sandstone represented any part of the Bunter Sandstones of the Midland or Northern Counties, but was more probably represented by what has been mapped in Yorkshire as the "Middle Marls and Sandstone" and the "Upper Magnesian Limestone" (a very misleading name). I have never stated that there could be no passage from the Permian up into the Trias, but just the reverse; I have also stated that there was a much greater conformity between the so-called Middle Marls and Upper Limestone (which are classed with the Permian in Yorkshire) with the Bunter Sandstone than with the Lower Magnesian Limestone below them. My anxiety is not so much for the retention of names,

but that every formation should be placed on its proper horizon, and I cannot believe that the proper horizon of the St. Bees Sandstone is the same as the Bunter Sandstones. W. T. Aveline.

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THE PERSIAN VOLCANO KOH-I-TAFTAN.

Sir,—In a footnote to a joint paper by my son and myself on the rocks of the Baluch-Afghan frontier (Q.J.G.S., vol. liii, p. 289), we gave a short account of a visit by Captain P. Molesworth Sykes to the volcano of Koh-i-Taftan, 12,600 feet high, situated near the eastern border of Persia, about 200 miles north of the Arabian Sea.

Captain P. Molesworth Sykes, who is now Consul at Sistan (Seistan), paid a second visit to Taftan (*Koh* means 'mountain' and *-i-* 'of') last January, and he writes to me as follows:—"When passing the eastern base of Taftan, Wood of the Telegraphs and myself tried to scale it from that side. At about 12,000 feet elevation we found seven orifices from which white vapour was being ejected with a noise like that of a steam-engine. The holes were very small and covered with stones, while, all around, were sulphur and sal-ammoniac. I collected here three tins full of the sulphur, the ash, and the stone. Almost at the summit the road was barred by perpendicular cliffs some 30 feet high, and so we could not reach it. The vapour issuing from the seven orifices (two being much bigger than the others) was visible for a distance of 10 or 15 miles, while the ground close to me was hot enough to break the bulb of my register. The climb was much steeper than on the south-west side, or perhaps I had not quite got over my seediness of the previous summer."

As so little is yet known about the Taftan volcano, and as it lies so much outside the range of ordinary travellers, the above brief account of Captain Sykes's second visit to this locality is interesting. The great heat of the ground near the orifices through which steam is still ejected under considerable pressure shows that the fires of this old volcano have not yet completely died out.

Captain Sykes kindly sent me the specimens he collected, but as they have not yet arrived I am afraid they have gone astray *en route*, or have been confiscated by some over-zealous Persian official who, in his care for the morals of Europe, may have thought that suspicious intercourse with the infernal regions ought not to be encouraged.

Should Captain Sykes again visit Koh-i-Taftan, it would be interesting if he could make a good representative collection of the solid rocks of that mountain found *in situ*.

I would remind those who may think it strange that an active volcano should have existed so far away from the sea that in Eocene times the sea flowed over what is now the Indus Valley into Baluchistan and Afghanistan (Manual Geol. India, 2nd ed., p. 494). This sea did not *commence* its retreat until the end of the Eocene period; and whilst it remained, the Koh-i-Safid range, of which Koh-i-Taftan forms a part, was probably not far removed from its shore. C. A. McMahon, Lieut.-General.

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